

THE CORRELATION AND TRILOBITE FAUNA  
OF THE BEDINAN FORMATION (ORDOVICIAN)  
IN SOUTH-EASTERN TURKEY

BY

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# THE CORRELATION AND TRILOBITE FAUNA OF THE BEDINAN FORMATION (ORDOVICIAN) IN SOUTH-EASTERN TURKEY

By W. T. DEAN

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## SYNOPSIS

The strata of the Bedinan Formation are described from the type region between Derik and Mardin, south-eastern Turkey. The rocks, which rest unconformably upon the Sosink Formation (Cambrian), are mostly mudstones and shales but the highest of these pass upwards, apparently without a break, into a group of sandstones. The Bedinan Formation represents only a part of the Caradoc Series and there is an abundant shelly fauna which includes the following trilobites: *Ampyx nitidus* sp. nov., *Marrolithoides orthogonius* sp. nov., *M. laticirrus* sp. nov., *Cryptolithus? inferus* sp. nov., *C? bedinanensis* sp. nov., *Dionide formosa anatolica* subsp. nov., *Dalmanitina proaeva* (Emmrich), *Kloucekia phillipsii euroa* subsp. nov., *Neseuretus* (*Neseuretinus*) *turcicus* subgen. et sp. nov., *Brongniartella levis* sp. nov., *Platycoryphe?* sp., *Colpocoryphe* sp., *Selenopeltis inermis angusticeps* subsp. nov. The trilobites, together with the less common brachiopods, exhibit marked Bohemian/Tethyan affinities and a tentative correlation with the Černín and Chlustina Beds of Czechoslovakia is suggested. The graptolite evidence, though fragmentary, probably indicates the *multidens* or *clingani* Zone and is broadly in keeping with that of the shelly faunas.

## I. INTRODUCTION AND ACKNOWLEDGMENTS

ALTHOUGH large outcrops of Lower Palaeozoic rocks occur in south-eastern Turkey, between the Tigris and Euphrates valleys, relatively little published information is available. The best-known exposures lie along an elongated belt, up to almost 3 km. wide, running east-south-east from a point 2 km. south-east of Derik towards Mardin, about 20 km. north-west of the Syrian frontier (for place names see Text-fig. 1). Tolun & Ternek (1952) gave a short description and small-scale maps of the Cambrian outcrops near Derik, and the highest part of the Cambrian succession as shown by them is known now to be Ordovician in age. Later Tolun (1960: 236) noted the occurrence of Silurian rocks (*sensu lato* including Ordovician) in south-eastern Turkey and mentioned a succession of 900 m. of marly and sandy beds with brachiopods, graptolites and trilobites underlying Cretaceous limestones at Bedinan. He remarked also on the similarity of the Bedinan Ordovician rocks to others found in bore-holes in northern Syria. The most important work dealing with this region is that of Kellogg (1960) who mapped a large area west of Mardin and gave detailed sections through all the stratigraphical subdivisions present, including the Cambrian and Ordovician rocks. He gave no comprehensive faunal lists but described the Bedinan Formation as containing, especially, "*Cryptolithus*" and "*Sowerbyella*-like brachiopods", which were held to indicate a Middle Ordovician age. Unfortunately Kellogg's report remains unpublished, but reference will be made to his work from time to time in this paper. A chart of the rock succession in south-eastern Turkey, from Pre-Cambrian to Quaternary, was compiled by Gernot Schmidt



FIG. 1. Sketch-map of south-eastern Turkey showing location of place-names mentioned in text.



in 1964 and revised in 1965. Again, this is a publication that I have been unable to find generally available, though some of its conclusions are noted later.

During the Spring of 1965 my wife and I carried out field-work in the region between Derik and Mardin. Both the Cambrian and Ordovician successions were examined; the latter are now described and it is proposed to describe the Cambrian faunas at a later date. Our work was greatly facilitated by the kindness of numerous Turkish friends. The Director, Dr. Sadrettin Alpan, and other members of the Maden Tetkik ve Arama Enstitüsü (M.T.A.), Ankara, generously placed the facilities of their organization at our disposal and we are particularly indebted to Dr. and Mrs. Kıragh, as well as to Mr. Günal Aygün who helped us in the field. In the Derik region we received much help from Dr. Karaköyünlü and members of the M.T.A. base-camp at the Mazıdag, whilst the work of Mr. Abdurrahman Tunç as guide and collector was invaluable. While working on comparative material in Czechoslovakia we received kindly assistance from Dr. Radvan Horný and Dr. Ladislav Marek. The graptolites we collected were examined by Dr. Isles Strachan. Finally, Prof. H. B. Whittington read the manuscript and made suggestions for its improvement. All specimens described in the present work are in the collections of the Department of Palaeontology, British Museum (Natural History).

## II. THE SUCCESSION AT BEDINAN

The village of Bedinan (sometimes written as Badinan or Bahdinan) lies in a valley about 20 km. east-south-east of Derik. The Ordovician rocks there form an inlier about 6 km. long and up to 3 km. broad elongated in an east-west direction. The inlier is bounded to the north by a prominent scarp and plateau of unconformable Cretaceous limestones, with a gentle northerly dip, and to the south by a large east-west dislocation, the Mardin Fault, which delimits massive Tertiary limestones having a variable southerly dip and sometimes slightly overturned. For the most part the Ordovician rocks comprise mudstones and shales with some intercalations of calcareous siltstone; the latter sometimes exhibit cone-in-cone structure and are more resistant to erosion than the adjacent mudstones. Higher in the succession the beds become more arenaceous and pass upwards conformably into a series of current-bedded sandstones, the age of which is discussed later.

The principal section of the Bedinan Formation occurs to the west of the village. The succession there is almost totally argillaceous, broken only by occasional, sometimes concretionary, bands of siltstone. The strata have a slightly variable dip of rather more or less than  $40^{\circ}$  to the north-north-east, and by means of a traverse in this direction it was possible to sample the rocks in ascending order. The location and horizons of the principal fossiliferous localities are shown in Text-figs. 2 and 3. The lowest beds presumably occurring here form a low-lying area immediately adjacent to hills of more resistant Tertiary limestones, and could not be examined owing to the cover of Alluvium. Consequently it was impossible to confirm the suggestion, made elsewhere in this paper, that these lowest strata may probably be correlated, at least in part, with the relatively restricted Ordovician succession of the Sosink district. However, the lowest beds sampled (at localities B.1 and B.2) yielded *Neseuretus* (*Neseuretinus*) *turcicus* sp. nov., *Colpocoryphe* sp., *Amphyx*

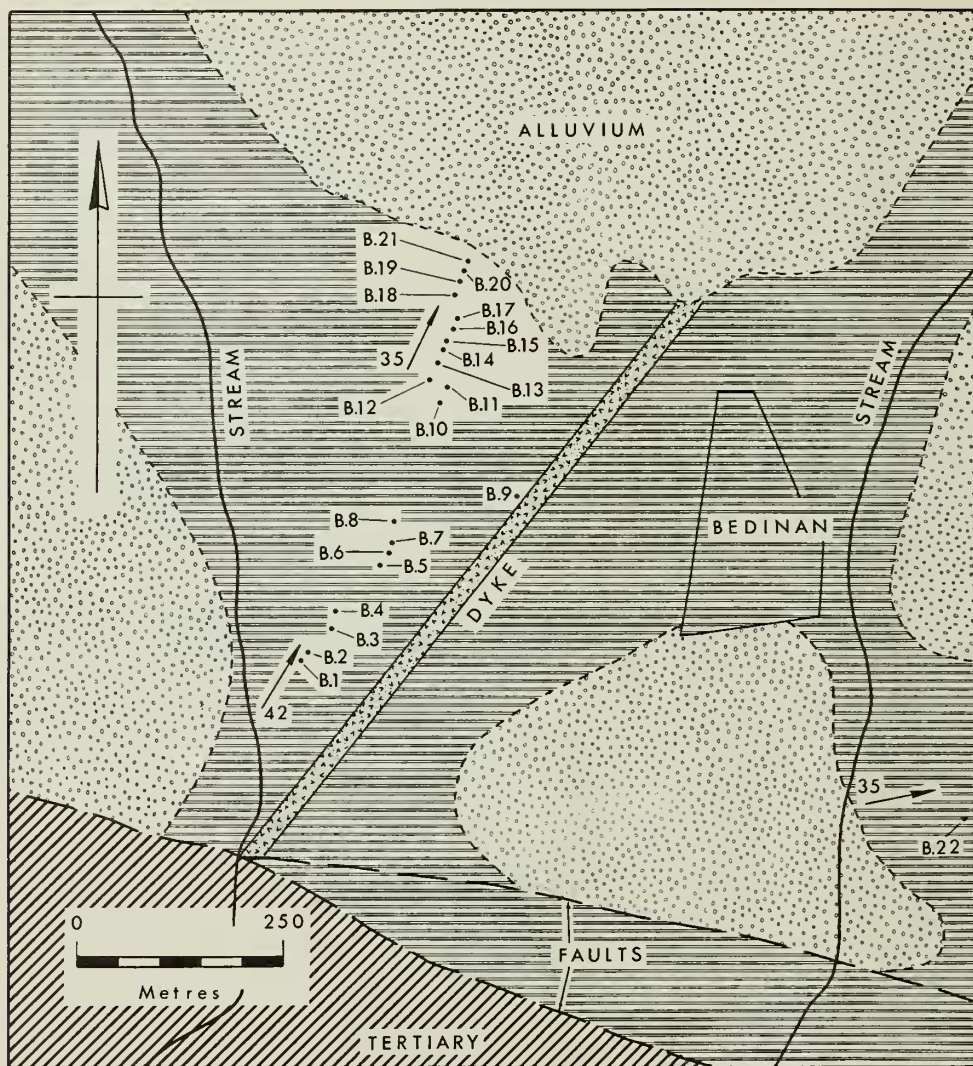


FIG. 2. Sketch-map showing principal fossil localities in the Ordovician rocks (horizontal shading) near Bedinan. Diagonal shading denotes Tertiary strata, whilst the remaining areas are covered by Alluvium.

*nitidus* sp. nov., *Cryptolithus*? and *Selenopeltis inermis angusticeps* ssp. nov. Three of these genera are known from near Sosink but were not recorded from the succeeding strata near Bedinan. *Dalmanitina* and *Kloucekia* did not prove suitable for attempts to subdivide the Bedinan Formation, and were found to persist, virtually unchanged, throughout.

Perhaps the least fossiliferous group of strata encountered in the traverse were those in the middle part of the section, including localities B.5–B.9. Nevertheless,

sufficient material was collected to show that the fauna differs in no way from that of the higher beds. The strata in this and lower parts of the succession were disturbed by the intrusion of a dyke alleged by Kellogg (1960) to be of Quaternary age. The adjacent shales are often broken and collecting there is difficult, but the degree of metamorphism is not high and at one point, near locality B.9, relatively undistorted fossils were obtained within a few centimetres of the contact.

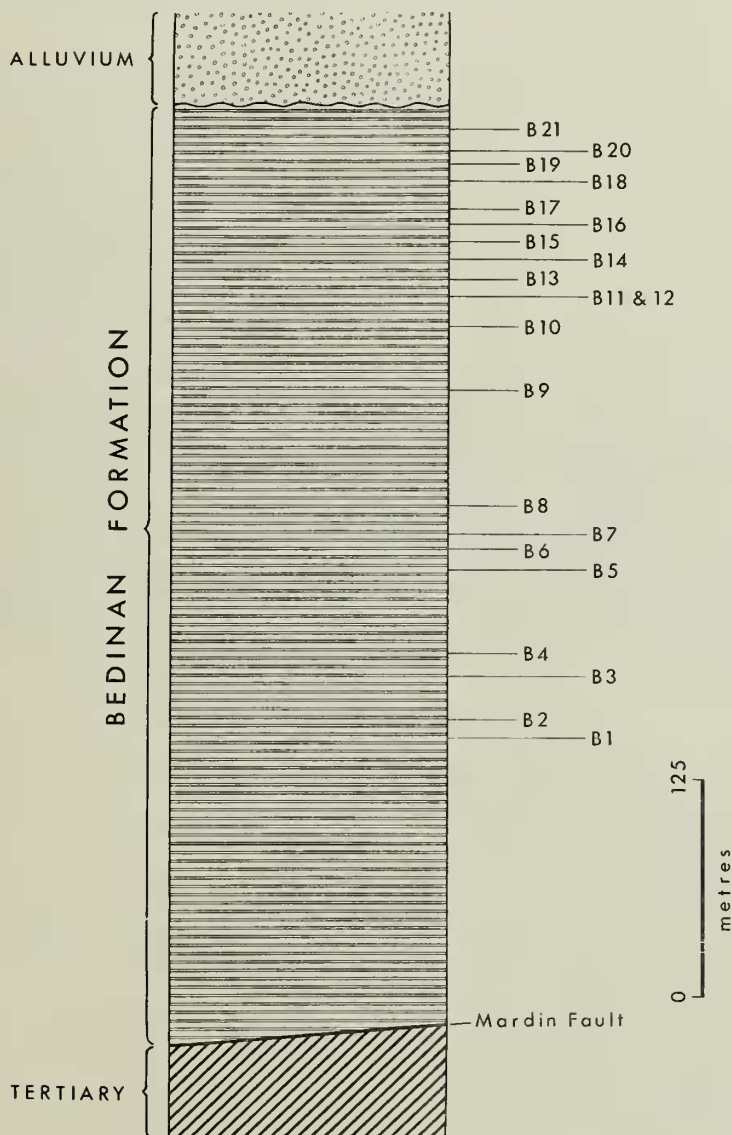


FIG. 3. Diagrammatic vertical section of the strata just west of Bedinan, showing horizons of principal Ordovician fossil localities. Shading as in Text-fig. 2.

The highest group of strata exposed in this section crop out along a hill-slope capped by superficial deposits. The beds mostly comprise grey-green shales which weather yellowish-brown and crumble easily. They are sometimes highly fossiliferous, containing especially trinucleid trilobites (*Cryptolithus?*), *Dalmanitina* and *Kloucekia*; the specimens are often compressed, but occasional micaceous siltstone bands may yield less distorted material. Brachiopods, including the genera *Aegiromena* and *Svobodaina*, of Bohemian affinities, were found at several localities but proved particularly abundant at B. 18-B. 21.

According to Kellogg, still higher strata near Bedinan may be examined in the area to the south-east of the village, and a traverse was made in that direction. His measured section shows the shale succession passing upwards into a thick series of sandstones, the age of which he put at "Middle? or Upper? Ordovician", these being followed in turn by unfossiliferous sandstones and shales of the Dadaş Formation, of "Lower? Silurian" age. More recently Schmidt (1965) has assigned the Bedinan Formation to both the Ordovician and the Silurian, followed (though the nature of the contact is questionable) by the Dadaş Formation, of alleged Devonian age. Whatever the relative merits of these two schemes, and there is as yet no definite faunal evidence to support either, it seems clear that the shales and mudstones forming the bulk of the Bedinan Formation pass upwards conformably into a series of massive and flaggy, often current-bedded sandstones. The higher, more massive, arenaceous strata yielded no more than occasional indeterminate fragments of inarticulate brachiopods, but in the lower sandstones I was able to find occasional specimens of *Dalmanitina* and *Kloucekia*, apparently identical with the forms occurring so abundantly in the argillaceous strata near Bedinan. As discussed elsewhere in this paper, the faunas of the argillaceous Bedinan Formation suggest an horizon in the upper half, though not the highest part, of the Caradoc Series. Consequently there is no necessity to regard at least the lower portion of the succeeding sandstone sequence as being any later than Caradoc in age.

#### FAUNAL LIST (for localities see Text-fig. 2)

- Ampyx nitidus* sp. nov. B. 2.
- Brongniartella levis* sp. nov. B. 18.
- Brongniartella* sp. B. 13, 19, 20.
- Cheirurid gen. et sp. indet. B. 12.
- Colpocoryphe* sp. B. 1, 2.
- Dalmanitina proaeva proaeva* (Emmrich) B. 1-3, 6, 7, 10, 11, 13-15, 17-22.
- Kloucekia phillipsii* (Barrande) *euroa* subsp. nov. B. 2-4, 6-8, 11-21.
- Cryptolithus? inferus* sp. nov. B. 1.
- Cryptolithus? cf. inferus* sp. nov. B. 2, 3.
- Cryptolithus? bedinanensis* sp. nov. B. 6, 8-16, 20, 22.
- Marrolithoides laticirrus* sp. nov. B. 3, 4.
- Marrolithoides* sp. B. 18? B. 21.
- Neseuretus* (*Neseuretinus*) *turcicus* subgen. et sp. nov. B. 2.
- Platycoryphe* ? sp. B. 20.



- Selenopeltis inermis* (Beyrich) *angusticeps* subsp. nov. B.1.  
 Ostracoda indet. B.8, 17, 22.  
*Aegiromena* sp. B.1-3, 6, 8, 9.  
*Lingula* sp. B.7.  
*Schizocrania* sp. B.1.  
*Svobodaina* sp. B.2, 6, 8, 10-12, 17-21.  
*Trematis?* sp. B.13.  
*Ribeiria* sp. B.3.  
 Miscellaneous, poorly-preserved bivalves B.1-3, 6-8, 16.  
*Sinuities* (s.l.) sp. B.3.  
 Hyolithids indet. B.10.  
*Lepidocoleus* sp.  
*Plumulites* sp. B.10, 12, 13, 16, 22.  
 Crinoid fragments, B.13, 20.  
*Climacograptus* sp. B.13.  
*Diplograptus* sp. B.8.

### III. THE SUCCESSION NEAR SOSINK

Although the Bedinan Formation forms an elongated E-W outcrop some 5 km. by 1 km. just east of the village of Sosink, the strata are not well exposed. Much of the ground is covered by superficial deposits derived from the adjacent high ground to the east where Cretaceous limestones, dipping south, form a plateau-like unconformable layer, and the best exposures are limited to a section running N.N.W.-S.S.E. along the dip, in the vicinity of the small stone building known as Ziyaret (Text-fig. 4). The rocks, like those of the Bedinan district, consist essentially of grey-green mudstones and shales with occasional, harder bands of siltstone. The beds dip just east of south at an average angle of about 38° though with slight variations, and the estimated thickness, calculated on the basis of a section through Ziyaret, is of the order of 440 m. In general the rocks are poorly fossiliferous, though specimens may be locally abundant, occurring in thin bands. The mudstones and shales are deeply weathered and crumble easily whilst the fossils are almost invariably preserved as orange, limonitic, internal and external moulds.

The northern boundary of the Ordovician outcrop here is a fault, separating the beds from Cambrian sandstones which form a conspicuous feature immediately to the north. The fault has an indeterminate, small downthrow to the south and is thought to mask the unconformable base of the Bedinan Formation. The lowest Ordovician beds exposed are not far from the fault-line and proved only sparingly fossiliferous, locality A.1 yielding a single specimen of *Colpocoryphe* and a few poorly-preserved brachiopods. Much of the Ordovician succession exposed in the hill-slopes to the south-east of Ziyaret proved almost barren, and only a small number of specimens was obtained from locality A.2 though these did include *Lasiograptus* sp. and the holotype cranium of *Selenopeltis inermis angusticeps* subsp. nov. in addition to the more commonplace fauna of *Dalmanitina*, *Aegiromena* and bellerophonitid gastropods (*Sinuities* s.l.).

The most prolific faunas of this area were collected from a number of localities in a small N.E.-S.W. valley excavated in shales some 180 m. north-west of the estimated position of the Cretaceous/Ordovician unconformity. In general the fossils were found in restricted horizons, no more than a few cm. thick, which could not be traced with certainty for more than a few metres. Trinucleid trilobites (*Marroliithoides*) formed easily the most abundant constituent of the fauna, though *Dalmanitina* and *Kloucekia* were not uncommon. The presence of *Dionide formosa*

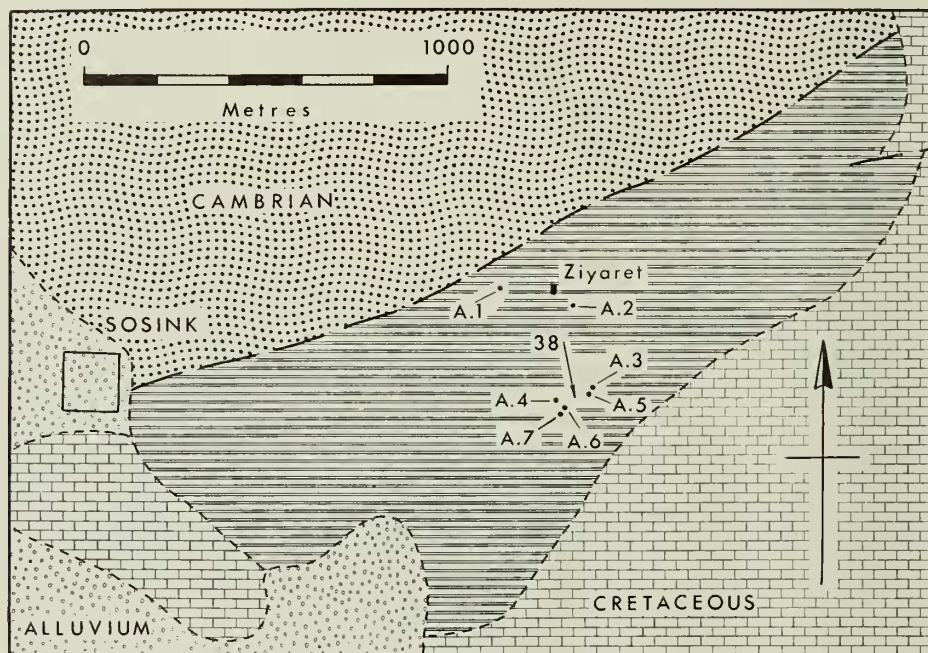


FIG. 4. Principal fossil localities in the Ordovician rocks near Sosink, 8 kilometres south-south-east of Derik. Shading as in Text-fig. 2, with addition of outcrops of Cambrian (dotted) and Cretaceous (brick pattern) rocks. Geological boundaries after Kellogg 1960.

*anatolica* at three localities was of particular interest; the species was found within a thickness of only a few metres of shales, and the genus is not yet known elsewhere in south-eastern Turkey. Brachiopods were relatively uncommon in the sections near Ziyaret, and comprised only *Aegiromena*, no doubt the "Sowerbyella-like brachiopods" of Kellogg's account. Very few representatives of the more abundant brachiopod faunas (including *Svobodaina*) of the Bedinan district were found, probably owing to the stratigraphically lower level of the Ziyaret strata. The highest Ordovician strata in this area could not be examined owing to the cover of Recent superficial deposits, which also obscures the junction of the Ordovician and Cretaceous rocks.

## FAUNAL LIST (for localities see Text-fig. 4)

Asaphid gen. et sp. indet. A.6.  
*Colpocoryphe* sp. A.3.  
*Dalmanitina proaeva proaeva* (Emmrich) A.1-6.  
*Dionide formosa* (Barrande) *anatolica* subsp. nov. A.3, 5, 7.  
*Marrolithoides orthogonius* sp. nov. A.3-6.  
 ?*Neseuretus* (*Neseuretinus*) *turcicus* subgen. et sp. nov. A.3.  
*Selenopeltis inermis* (Beyrich) *angusticeps* subsp. nov. A.2, 3.  
*Aegiromena* sp. A.2, 3, 4, 5, 7.  
*Svobodaina* sp. A.3.  
*Sinuities* (s.l.) sp. A.2, 6.  
*Redonia* sp. A.3.  
*Ribeiria* sp. A.3.  
 Bivalve indet. A.3.  
 Miscellaneous Ostracoda A.3, 6.  
 Hyolithids indet. A.3.  
*Plumulites* sp. A.3, 4, 5, 6, 7.  
*Climacograptus* sp. A.3.  
*Lasiograptus* sp. A.2.  
 Orthocone cephalopod indet. A.3.

## IV. AGE AND RELATIONSHIPS OF THE BEDINAN FAUNAS

Perhaps the most obvious feature of the Beninan shelly faunas is their overall resemblance to those of the Bohemian region, even though the relevant Turkish forms are, for the most part, at least subspecifically distinct. The Bohemian trilobite species identical with, or most closely related to, those of the Bedinan Formation are as follows: *Dalmanitina proaeva proaeva* (Emmrich), *Kloucekia phillipsii* (Barrande), *Dionide formosa* (Barrande) and *Selenopeltis inermis inermis* (Beyrich) [= *S. buchi* (Barrande)]. From accounts of the Bohemian faunas published by Havlíček *et al.* (1958) and Šnajdr (1956) the ranges of these species are as follows: *D. proaeva proaeva*, Černín & Chlustina Beds; *Dionide formosa*, Černín Beds. The lists of Havlíček *et al.* show that *Kloucekia phillipsii* occurs only in the Chlustina Beds, its type horizon, but Šnajdr records it from the Drabov Beds (basal Caradoc Series) to the Chlustina Beds. *Selenopeltis inermis* has an extended vertical range and is alleged to occur as low as the Dobrotiva Beds (Llandeilo Series) and as high as the Bohdalec Beds (topmost Caradoc). The species has been recorded (as *S. buchi*) by Seilacher (1963) from the Sinat Shales, of unspecified Ordovician age, in northern Iraq, not far to the east of the Bedinan district.

In the Bedinan Formation *Dalmanitina proaeva proaeva* and *Kloucekia phillipsii* occur throughout most of the fossiliferous sequence, an association suggesting that a tentative correlation with the combined Černín Beds and Chlustina Beds is not unreasonable. *Dionide formosa anatolica* has been found only in the Sosink district, in the lower part of the Bedinan Formation, and this geological horizon may not be far removed from that of *D. formosa* in the Černín Beds.

The evidence of the remaining trilobites is inconclusive, though the species present may be potentially useful for correlation when other Tethyan faunas are better documented. *Marrolithoides* is a Llandeilo/Caradoc genus in north-western France and the Anglo-Welsh area, where *Cryptolithus* is found in the Llanvirn and Llandeilo Series, whilst *Colpocoryphe* is a fairly common constituent of Mediterranean faunas ranging in age from Arenig to Caradoc Series. *Brongniartella* is, above all, a genus of the Caradoc Series in the Anglo-Welsh area, most of its other occurrences in Europe and Scandinavia being as a single, widespread species, *B. platynota* (Dalman), in the Ashgill Series. Its appearance in the Turkish Caradoc is rather unexpected but suggests an easterly migration along the Tethys during Caradoc times, though its subsequent migration and development are far from clear. The new subgenus *Neseuretus* (*Neseuretinus*) is of particular interest as it may provide a link between European and Asian faunas of generally similar age. The horizon of *N. (Neseuretinus) birmanicus* (Reed) in Burma and China is obscure in terms of modern stratigraphy, but it forms part of Whittington's (1966 : 723) Caradoc *Encrinurella* fauna. As pointed out elsewhere (Dean 1967) the age of the *Encrinurella* fauna may vary within the Caradoc Series, and is apparently greatest in Australasia.

The number of graptolites found during the present field-work was disappointingly small and the specimens are poorly preserved, but Dr. Strachan has kindly examined them and supplied notes on their horizon. They include *Diplograptus* (s.s.) sp. and *Climacograptus* sp. near Sosink. Although little precise information can be given regarding their zonal position, Dr. Strachan considers all the specimens to be of Caradoc age. "They are not pre-*gracilis* [Zone], could well be *multidens-clingani* [Zone], and are unlikely to be *linearis* [Zone] or later" (personal communication). Such an assessment accords well with the evidence of the trilobites, and supports a broad correlation with the Černín and Chlustina Beds, sub-divisions which, in Bohemia, are overlain by the Bohdalec Beds, regarded as the topmost part of the Caradoc Series (Bouček 1937 : 454).

All the other animal groups represented in the Bedinan Formation are in a minority by comparison with the trilobites. Brachiopods may be locally abundant, particularly in the higher strata west of Bedinan, but are often poorly-preserved. They include, *inter al.*, the genera *Aegiromena* and *Svobodaina* (Havlíček 1950 : 38, 109), indicating once more a close relationship with the Caradoc Series of Bohemia. The remainder of the fauna consists mainly of molluscs, represented by the almost ubiquitous *Redonia* and nculids, together with gastropods, usually smooth forms of bellerophonitid type generally resembling *Sinuities*. The alleged phyllopod genus *Ribeiria* was found uncommonly near both Bedinan and Sosink. Hyolithids occur in small numbers but are usually incomplete and poorly-preserved, whilst plates of the machaeridian genera *Lepidocoleus* and *Plumulites* are not uncommon. All these groups form an assemblage broadly similar to many others in the Tethyan region, extending as far west as Portugal, Normandy, Wales and, probably, Florida. Such assemblages range in age from Arenig to Caradoc Series and many of the constituents, apart from the more obvious, diagnostic forms, exhibit relatively little morphological change, although a modern revision of the molluscs is still awaited.



## V. SYSTEMATIC DESCRIPTIONS

Family **RAPHIOPHORIDAE** Angelin, 1854Genus **AMPYX** Dalman, 1828***Ampyx nitidus*** sp. nov.

(Pl. 5, figs. 5, 8-11)

DIAGNOSIS. *Ampyx* with broad, pear-shaped glabella, its greatest breadth measured one-third of distance from base of frontal spine to occipital furrow. Only traces of glabellar lobes. Triangular fixigenae relatively short, about one and a half times as broad as long. Pair of large pits near outer ends of posterior border furrow. Pygidium short, with median length about one-third frontal breadth. Axis poorly defined with at least two small axial rings. Side lobes have one pair deep, straight, pleural furrows.

HOLOTYPE. It. 1181 (Pl. 5, fig. 8).

PARATYPES. It. 1180 (Pl. 5, fig. 10); It. 1207 (Pl. 5, fig. 5); It. 1208 (Pl. 5, fig. 9); It. 1209 (Pl. 5, fig. 11).

LOCALITY AND HORIZON. The species was found at only one locality, B.2, south-west of Bedinan, in the lower part of the Bedinan Formation there. It was accompanied by *Cryptolithus? inferus*, *Neseuretus* (*Neseuretinus*) *turcicus* and inarticulate brachiopods (listed as *Schizocrania* sp.).

DESCRIPTION. The cranidium, excluding the frontal spine which has not been found preserved, is subtriangular in plan with median length about half of the basal breadth. The glabella is subtrapezoidal in outline, bluntly pointed frontally, with the sides diverging forwards at about 50°. The maximum breadth is slightly more than three-quarters of the median length of the glabella (excluding frontal spine and occipital ring), and is measured across the intersection of the sides and the front of the fixigenae. About one-third of the glabella lies in front of the line of maximum breadth. Although there has been some dorsal compression, there can be no doubt that the original glabellar outline expanded forwards markedly. The glabella stands a little higher than the fixigenae and is separated from them by broad, shallow, slightly curved axial furrows which become deeper frontally and curve inwards, though the region of the anterior border is not preserved. The glabella carries only poorly-defined traces of lobation. A transverse, basal segment, representing the 1p glabellar lobes, is delimited by a pair of shallow 1p glabellar furrows which run inwards and slightly forwards to join medially, where they become almost obsolete. Immediately in front of the basal glabellar segment are traces of a pair of semi-elliptical 2p glabellar lobes. The fixigenae are subtriangular and of moderate size, with about one-third of the length of the glabella projecting in front of them. The margins are straight and run backwards slightly for a short distance from the axial furrows as far as the facial sutures. Each of the latter meets the cephalic margin at an acute angle and from there pursues a gently flexuous course, at first slightly concave outwards and then slightly convex, before cutting the posterior border immediately outside a large, slot-like pit in the posterior border furrow. The

occipital ring is low, moderately broad (*sag.*), continuous with, but projecting backwards beyond, the transversely straight, ridgelike posterior border. The occipital furrow is mostly shallow but deepens a little abaxially where it joins the posterior border furrow. The latter is broad (*exsag.*) and shallow with a pair of pits sited near the outer ends [see above].

A single incomplete hypostoma was found (Pl. 5, fig. 10), so small as to probably represent an immature individual. The median body is moderately and almost uniformly convex, bounded posteriorly and posterolaterally by a narrow, slightly raised border. The posterior margin is almost transversely straight, as are the posterior portions of the lateral margins which converge slightly backwards and meet the posterior margin at rounded, obtuse angles.

The thorax is not known.

One example of the pygidium was found, apparently only slightly compressed. The outline is transversely subelliptical, about three times as broad as long, its frontal margin transversely straight except medially, where a small articulating half-ring projects forwards slightly. The axis is triangular in plan, with the sides covering backwards at about  $35^{\circ}$ . It is not strongly defined, stands only a little higher than the side-lobes, and reaches the posterior margin; two axial rings are visible. The side-lobes carry one pair of deep, straight pleural furrows, extending almost to the margins and delimiting a pair of half-ribs which are declined anterolaterally to form a pair of small facets. The impression of a broad doublure is covered with fine terrace-lines which run subparallel to the margin.

DISCUSSION. *Ampyx nitidus* is one of the youngest species assigned to the genus and exhibits marked differences from early forms of *Ampyx*. The type species, *A. nasutus* Dalman (see Whittington 1950 : 554) has a narrower, less divergent glabellar outline, with a smaller proportion of the glabella projecting in front of the fixigenae, which are also relatively longer. The Swedish species, which is of Upper Arenig age, possesses a pair of pits at the outer ends of the posterior border furrow, as does *A. nitidus*. This feature is not seen, or is less well developed, in species such as *Ampyx linleyensis* Whittard (1955 : 18), from the Lower Llanvirn of the Shelve Inlier, and the Shropshire form is also distinguished by its broader glabella with smaller frontal projection, as well as by the well differentiated glabellar and alar lobes. The pygidium of the Turkish species is relatively shorter than that of *Ampyx nasutus* or *A. linleyensis*, has a more rounded margin, and the axis is less well defined and segmented. The hypostoma of *A. nasutus* is not yet known but that of *A. linleyensis* has a pear-shaped outline, posterior wings and lateral notches not seen in the incomplete specimen attributed here to *A. nitidus*.

*Ampyx virginianensis* Cooper (1953 : 16), from the Lower Edinburg Formation (early Caradoc) of Virginia, has been redescribed in detail by Whittington (1959 : 465). Like *Ampyx nitidus* it has a relatively short, rounded pygidium but differs from the Turkish species in having a shorter frontal projection of the glabella, as well as more distinct glabellar furrows and a strong development of alar lobes. As far as can be judged the hypostoma of *A. nitidus* appears to be more like that of *A. virginianensis* than that of *A. linleyensis*. *Ampyx camurus* Raymond (Whittington 1959, pl. 30, figs. 15, 18, 19), also from the Edinburg Formation, has a cranium

generally similar to that of *A. nitidus* but the glabella is slightly narrower and the fixigenae are relatively longer, whilst the pygidium has a more triangular outline.

*Ampyx nitidus* bears a general resemblance to *A. abnormalis* Yi (1957 : 557, pl. 5, figs. 3a-e), also of Caradoc age, from the Yangtze-Gorge District of China, but the Turkish species may be distinguished by its slightly longer cephalon, with the front of the glabella extending a little farther in front of the fixigenae, and the slightly shorter, more rounded pygidium.

### Family **TRINUCLEIDAE** Hawle & Corda, 1847

#### Subfamily **CRYPTOLITHINAE** Angelin, 1854

*Marrolithoides*, nowadays accorded generic rank, was erected by Williams (1948 : 78) as a subgenus to differentiate *Marrolithus*-like trilobites in which the lateral cephalic margins are approximately parallel, the arrangement of fringe-pits is relatively simple, and the cephalic fringe is uninflated anterolaterally, except in gerontic forms. Since then Whittard (1956 : 49, 63) has redefined the genus and transferred William's species *M. anomalis*, regarded by its author as atypical of *Marrolithoides*, to *Marrolithus*. According to Whittard the criteria for distinguishing *Marrolithoides* are now as follows : (a) the cephalic outline is subrectangular ; (b) the fringe is not distended anterolaterally and there is no abnormal increase in pit-diameter there ; (c) auxiliary pits are generally present in  $E_1$  ; (d)  $E_1$ ,  $I_1$  and, sometimes,  $I_2$  are continuous frontally ; (e)  $I_1$ - $I_2$  pseudogirder is almost as strongly developed as the normal  $E_1$ - $I_1$  girder. Specimens from the Bedinan Formation which possess these features, together with unmistakable anterolateral angulation of the cephalic outline, may therefore reasonably be assigned to *Marrolithoides*. Individuals of this type occur in the succession east of Sosink and also at locality B.3, in the lowest part of the succession exposed near Bedinan, but the numerous trinucleids collected suggest that such generic limits as those listed above may be somewhat arbitrary. The angular cephalae of B.3 are associated with smaller individuals—apparently immature examples of the same species—in which the outline is rounded anterolaterally. Similarly-rounded cephalae, but of relatively large size and therefore presumably adult forms, occur at locality B.1 as well as from B.5 to the top of the succession near Bedinan. Trinucleid cephalae possessing such rounded outlines together with a single row of pits external to the girder would normally be termed *Cryptolithus* sensu stricto, and the name is used here, with some doubt, for most of the Turkish specimens described. The latter, in general, show a greater development of concentric rows of pits than is customary for such forms as the type species *C. tessellatus* Green, from the Caradoc of eastern North America, and it is likely that the affinities of the Turkish specimens lie, rather, with species in Bohemia as well as those described by Whittard (1958 : 72-77) from the Llanvirn and Llandeilo Series of the Shelve Inlier. The latter group of species was said by Whittard to be distinct from those in North America, but there is as yet no evidence that they merit generic separation. On the basis of the above criteria the trinucleids of the lowest Bedinan Formation are placed in *Marrolithoides*. The

remainder are attributed questionably to *Cryptolithus* and there is a small stratigraphical overlap of the two genera in the lower strata exposed south-west of Bedinan. The terminology used in the following descriptions is that of Whittard (1955 : 27) and the pit counts refer to half the cephalic fringe.

Genus **MARROLITHOIDES** Williams, 1948

***Marrolithoides orthogonius*** sp. nov.

(Pl. 1, figs. 1-9)

DIAGNOSIS. *Marrolithoides* with subrectangular cephalic outline and three concentric rows of pits [ $E_1, I_{1-2}$ ] developed frontally, except for small irregular group near sagittal line.  $E_1, I_2$  pits of similar size;  $I_1$  pits slightly larger.  $I_{3-5}$  present, but  $I_6$  represented by only few small pits. Average pit-count:  $E_1 + e_1$  26,  $I_1 + i_1$  21,  $I_2 + i_2$  21,  $I_3 + i_3$  18,  $I_4 + i_4$  17,  $I_5 + i_5$  about 14 or 15 [for variation see description].

HOLOTYPE. It. 1200 (Pl. 1, fig. 6).

PARATYPES. It. 747 (Pl. 1, fig. 4); It. 749 (Pl. 1, fig. 8); It. 760; It. 762 (Pl. 1, fig. 7); It. 803 (Pl. 1, fig. 2); It. 806 (Pl. 1, fig. 5); It. 812 (Pl. 1, fig. 1); It. 818 (Pl. 1, fig. 9); It. 819 (Pl. 1, fig. 3).

LOCALITIES AND HORIZONS. The holotype and most of the paratypes are from the Bedinan Formation at locality A.3 in the section near Ziyaret, some 1300 m. east of Sosink. This locality yielded the species in greatest abundance, some 60 specimens, whilst more than 20 were obtained from the same section at locality A.6, whence came two of the paratypes. Localities A.4 and A.5 produced only a few specimens of *M. orthogonius*.

DESCRIPTION. The cephalon is approximately subrectangular in outline, more than twice as broad as long (excluding spines), though the proportions are obviously affected by dorsal compression, so that the cephalic fringe now appears flattened, in contrast to its original, steep declination outwards. The frontal margin, gently convex forwards in plan, forms a broad curve and meets at an obtuse angle the lateral margins, which are almost straight and converge forwards gently. The degree of anterolateral angulation seems to be genuinely variable, ranging from a broad curve, particularly in smaller specimens, to a relatively sharp angle. In one case (Pl. 1, fig. 5) the angle is marked by a blunt projection developed from the margin at about R 16. The glabella is about twice as long as broad, stands high above the cheek-lobes, and narrows backwards slightly to a shallow occipital furrow which deepens laterally into a pair of apodemal pits. The best-preserved specimens show a small, median tubercle which is slightly more conspicuous on the internal than on the external mould. The glabella extends forwards a little beyond the cheek-lobes, from which it is separated by deep, straight, axial furrows, so that the cephalic fringe narrows (*sag.*) frontally. Each axial furrow contains a prominent hypostomal pit sited just behind the pitted fringe. Some specimens show faint, lateral indentations of the glabella, suggesting almost obsolete glabellar furrows, but in most the



glabellar margins are entire. One of the smallest specimens (*Meraspis*, Degree unknown, Pl. 1, fig. 7) shows, in addition to traces of eye-ridges, a conspicuous development of alar lobes; the latter are less obvious on both an example of *Meraspis*, Degree 4 (Pl. 1, fig. 9) and slightly larger cephalae (Pl. 1, figs. 1, 2), and are absent from the presumed adults. A deep occipital furrow separates the glabella from the narrow (*sag.*) occipital ring, which is steeply inclined backwards, produced upwards and back to form a thorn-like occipital spine approximately half the length of the glabella. The posterior border is narrow (*exsag.*) and transversely almost straight as far as the fulcrum, where it flexes backwards a little way, becoming flange-like and indented to form a pair of articulating sockets. Beyond the fulcrum the posterior margins of the cephalic fringe are almost transversely straight, and the backward projections of the fringe (so-called posterior wings) which characterize certain of the Bedinan Formation trinucleids, and are sometimes very large, are here noticeably absent. The small *Meraspis* figured here (Pl. 1, fig. 7) shows the genal angles set well forwards, in front of the line of the posterior border furrow. This feature is shared with other cryptolithinids, and the position of the genal angles moved progressively backwards during ontogeny. Only incomplete examples have been found showing the librigenal spines; these are directed backwards and slightly outwards from the genal angles, and apparently resemble those found in other members of the Cryptolithinae. Many specimens exhibit a conspicuous reticulation of the cephalic test, but in others it is less well developed or even, occasionally, almost absent. It is not yet clear whether such variation is original or due to vagaries of preservation. When present the reticulation is confined to the cheek-lobes and the axial portion of the glabella (see Pl. 1, fig. 1).

The cephalic fringe is narrow (*sag.*) in front of the glabella, becomes broader laterally, attaining its maximum opposite the antero-lateral portions of the cheek-lobes, and narrows a little laterally, finally broadening again near the posterior border, where it expands around the posterolateral extremities of the cheek-lobes. Three concentric rows of pits,  $E_1$  and  $I_{1-2}$ , are almost continuous frontally, except for a small, irregular area near the sagittal line which appears to be of specific importance. At this point small cephalae (see Pl. 1, fig. 4) exhibit a group of three pits arranged in a triangle with apex directed backwards. The anterior two pits form part of  $E_1$ , whilst the hindmost pit may probably be regarded as part of  $I_1$ , though sometimes it occupies a position between  $I_1$  and  $I_2$ . In larger cephalae (see Pl. 1, fig. 8) the group of three pits is replaced by one of four pits, three of them corresponding to, and arranged in-line with,  $E_1$ , and the centre pit of the three arranged radially with the fourth pit so as to form a radial row,  $R_0$ , coincident with the sagittal line. Additional concentric rows of pits are developed as follows:  $I_3$  from  $R_3$  or  $R_4$ ;  $I_4$ , from  $R_6$  or  $R_7$  (occasionally  $R_5$ );  $I_5$  from  $R_9$  (less commonly from  $R_{10}$  or  $R_{11}$ );  $I_6$ , when present, is developed only as a few pits in the area denoted by  $R_{11}$  to  $R_{15}$ , or thereabouts. The pits of  $E_1$  and  $I_2$  are of similar size and show almost no variation in size over the whole of their length. The pits of  $I_1$  are slightly bigger, also uniform in size, and a low ridge is developed between  $E_1$  and  $I_1$ , particularly anterolaterally. Although all the material is somewhat compressed there is a suggestion that the corresponding portions of  $I_1$  may have



been raised slightly above the adjacent rows, but there is no indication of distended pits such as are found in the analogous parts of *Marrolithus*. The pits internal to  $I_2$  diminish slowly in size towards the cheek-lobes and are often set in shallow radial sulci; the latter may be exaggerated by crushing, which may also overemphasize the radial extension of such sulci to include, apparently, pits of  $I_1$  and  $I_2$ ; The number of pits along the posterior border of the fringe is generally about eight, in addition to a single, larger, apodemal pit. Apart from the area of irregular pitting near the sagittal line described above, the arrangement of pits is remarkably orderly, with a strong radial arrangement persisting from  $R_1$  to within a few pits of the genal angles. Auxiliary pits occur only uncommonly, though an occasional specimen may have an extra pit or so on one side of the cephalon and not on the other. An example is shown in Pl. 1, fig. 6, with  $E_1$  containing two intercalated pits, between  $R_3$  and  $R_4$ , and between  $R_8$  and  $R_9$ ; these occur only on the right side of the cephalon. The number of pits present in the fringe is as follows, the first number indicates the number of pits most commonly found, the second, in brackets, shows the range of variation:  $E_1$  26 (23–28),  $I_1$  21 (20–24, rarely 25),  $I_2$  21 (20–22, rarely 23),  $I_3$  18 (17–19, one specimen with 21),  $I_4$  17 (15–18),  $I_5$  approx. 14–15, but most material not suitably preserved;  $I_6$  either not developed, or present only as a few pits from a point varying from  $R_{11}$  to  $R_{15}$ .

The ventral side of the cephalic fringe carries an  $E_1/I_1$  girder which is well defined anteriorly, less so laterally, and finally becomes more pronounced again just before attaining the genal angle, where it forms a well-marked ridge which is continued along the librigenal spine. Between  $I_1$  and  $I_2$ , and between  $I_2$  and  $I_3$ , are pseudogirders, each successively a little less strongly developed than the last but nevertheless well defined, and traces of additional pseudogirders occur between the remaining  $I$  rows.

The thorax is known only from poorly-preserved material of characteristic cryptolithinid form, that is to say it contains six segments, the first of them macropleural. Each pleura ends in a blunt point, directed posterolaterally, and carries a broad (*exsag.*), straight, shallow, pleural furrow which runs gently backwards abaxially from the axial furrow almost to the pleural tip, near which it curves backwards slightly and dies out.

The pygidium is subtriangular in plan with the transversely straight anterior margin broken only by the articulating half-ring. The lateral margins, defined by a small, raised ridge, are straight and widely divergent over the posterior two-thirds but then curve forwards to the anterolateral angles. The axis stands slightly higher than the flattened side-lobes and is gently rounded in cross-section. The anterior two-fifths of the axis carry three well-defined axial rings, gently curved and convex forwards in plan. The rings, which are not sharply delimited laterally, are separated by ring furrows which are continuous laterally with markedly shallower furrows traversing the side-lobes and running gently backwards to reach the marginal rim. The remainder of the axis has traces of several small, poorly-defined rings, and the tip merges into the marginal rim, here less sharply defined. The side-lobes carry only traces of furrows in addition to those continuous with the first three ring furrows. The pygidium of *Meraspis*, Degree 4 (Pl. 1, fig. 9) is semielliptical in plan and proportionately shorter than that of the adult trilobite.

DISCUSSION. For convenience the species of *Marrolithoides* are discussed together (see p. 100).

*Marrolithoides laticirrus* sp. nov.

(Pl. 2, figs. 1, 3, 5, 9, 11, 13, 14)

DIAGNOSIS. *Marrolithoides* with cephalic outline broadly rounded frontally, angular anterolaterally. Large posterolateral extensions of fringe. Reticulation of glabella and cheek lobes characteristic in both small and, to lesser degree, larger individuals. Broad cephalic fringe contains four continuous concentric rows of pits ( $E_1$ ,  $I_{1-3}$ ) frontally; remaining rows well developed. Pit count relatively high, average as follows:  $E_1$  36-38,  $I_1$  27-30,  $I_2$  26-30,  $I_3$  29,  $I_4$  up to 26,  $I_5$  21, small development of  $I_6$ . Pygidium with about nine axial rings and five pairs pleural ribs.

HOLOTYPE. It.683 (Pl. 2, fig. 5).

PARATYPES. It.690 (Pl. 2, fig. 11); It.706 (Pl. 2, fig. 3); It.707 (Pl. 2, fig. 1); It.708 (Pl. 2, fig. 13); It.712 (Pl. 2, fig. 14); It.738 (Pl. 2, fig. 9).

LOCALITIES AND HORIZONS. The type material is from locality B.3, south-west of Bedinan, where it was found in moderate abundance (sample of 22 specimens) associated with *Dalmanitina*, *Kloucekia* and a single example of *Cryptolithus? inferus*. A few specimens from B.4, about 12 m. higher in the succession, differ from the type material in only small details and are considered to fall within the limits of variation for the species.

DESCRIPTION. The cephalon has a maximum breadth about two and a quarter times the median length. The lateral margins are straight or very slightly concave, and typically almost parallel, although some specimens exhibit a slight divergence or convergence which may have been exaggerated by crushing. The anterior margin of the cephalon is arched forwards, moderately in smaller cephalia but more strongly in larger specimens. One of the latter, the holotype (Pl. 2, fig. 5), shows the lateral and anterior margins meeting at obtuse but sharply defined angles which are in line with the highest point of the glabella, about one-third of the distance from the front of the glabella. The cephalic fringe is notably broad, with a frontal breadth (*sag.*) [measured on dorsally compressed specimens] equal to two-fifths of the glabellar length. Its maximum breadth is anterolaterally, behind which it narrows a little, just in front of the line of the posterior border furrow, before expanding again towards the genal angles, which are set well back, at the end of large genal prolongations. At the genal angles the lower lamella of the fringe is produced backwards to form a pair of prismatic librigenal spines, curving gently outwards at first and then inwards, with a length at least two and a half times that of the glabella. There is a strong, concentric arrangement of fringe-pits, usually with four continuous rows ( $E_1$ ,  $I_{1-3}$ ) developed in front of the glabella, but occasionally only three rows ( $E_1$ ,  $I_{1-2}$ ).  $I_4$  may be developed as far forwards as  $R_3$ . The pits of  $I_1$  are conspicuously the largest and maintain an almost uniform size to the genal angle. The

pits of  $I_2$  are slightly smaller whilst those of  $E_1$  and  $E_3$  are slightly smaller still. The pits of subsequent I rows diminish steadily in size inwards from the girder. All the specimens are moderately compressed dorsally but most show a development of a sharp concentric ridge sited anterolaterally between  $E_1$  and  $I_1$ , and extending from about R6 to R2 or thereabouts. Some show a suggestion of a smaller  $I_{1-2}$  ridge anterolaterally. These structures suggest that the uncrushed cranidia may originally have had the anterolateral portions of  $I_1$  raised slightly above neighbouring rows. The number of pits in each of the rows  $I_{1-4}$  is fairly uniform but the number in  $E_1$  is conspicuously higher and many of the pits there do not fit easily into a radial pattern. The region of the fringe internal to the girder exhibits a strong radial arrangement, comprising from seventeen to nineteen radii which cover an area extending to within a few pits (generally 3 or 4) of the posterior border. A sample of 15 specimens from the type locality yielded the following counts:  $E_1 + e_1$  36-38 [in small cephalo 29-34, rarely 26];  $I_1 + i_1$  26-30 [occasionally 23-25];  $I_2 + i_2$  26-30 [occasionally 22-25];  $I_3 + i_3$  26-29 [occasionally 23-25];  $I_4 + i_4$  is well developed in the holotype, with 27 pits from R3, but small cephalo may have as few as 18 pits;  $I_5 + i_5$  10-19 [from R8 in a large cephalon, from R12 to R14 in a small one];  $I_6$  only a trace, perhaps a few pits from about R14-R16. At locality B.4 a small sample of three cephalo was obtained. These have a smaller pit count (33-34) for  $E_1 + e_1$  than the type material but are otherwise similar and are attributed to the same species. The glabellar outline is clavate, expanded frontally where the maximum breadth is slightly less than two-thirds of the median length. Two pairs of lateral depressions represent the glabellar furrows, and the frontal glabellar lobe does not invade the cephalic fringe to any marked degree. The cheek-lobes are plump, quadrant-shaped, and their dorsal surface, like that of the axial portion of the glabella, is covered with a fine, mesh-like pattern of raised ridges. An occasional specimen shows a small, median tubercle at the apex of the glabella. The small occipital ring is produced backwards and upwards to form a small, sharp occipital spine. On the ventral surface of the fringe the girder is moderately developed, only slightly stronger than the pseudogirders  $I_1/I_2$  and  $I_2/I_3$ .

The remainder of the exoskeleton is generally similar to that found in other members of the subfamily, with six thoracic segments of characteristic type. The subtriangular pygidium has slightly flexed, steeply declined margins surmounted by a thin, dorsal rim. There are about nine small axial rings separated by ring furrows, the anterior members of which cross the shallow axial furrows and are continuous with five or six shallow pleural furrows.

DISCUSSION. *Marrolothoides orthogonius* is the earliest-occurring trinucleid species yet known in the Bedinan Formation, and was found only in the upper part of the section east of Sosink. The not inconsiderable thickness of underlying shales there has yet to yield trinucleids, but the beds in question are inadequately exposed. *M. orthogonius* has not been found outside the Ziyaret district nor, conversely, have any of the trinucleid species from Bedinan been found elsewhere. This may be accounted for by the fact that the Ziyaret strata are probably older than the lowest seen west of Bedinan, and if any overlap of the sections occurs one would expect it

to involve the strata under the alluvial cover adjacent to the Tertiary limestones cropping-out some 750 m. south-west of Bedinan.

Judging from Williams's drawings (1948, pl. 6, figs. 5, 7) the Welsh forms of *Marrolithoides* would appear to have very small fringe pits, but Whittard's (1956, pl. 9, fig. 3) photograph of the holotype of *M. simplex*, the type species, shows pitting of characteristic cryptolithinid dimensions, with the pits of  $I_1$  slightly larger than the rest, a feature seen also in the Turkish material. The Anglo-Welsh species of *Marrolithoides* illustrated by Whittard (1956) possess cheek-lobes which are relatively much larger than those of the Turkish species; consequently the cephalic fringes of the latter appear much broader although, in terms of concentric rows of pits, there is not much difference. *M. orthogonius* has a pit count not markedly different from that of *M. arcuatus* Whittard, of lowest Caradoc age at Shelve. However, the Turkish species tends to have more pits in  $E_1$  and a larger development of  $I_5$ , whilst a triangular group of 3 or 4 pits (1 pit in  $I_1$  and 2 or 3 pits in  $E_1$ ) forms a conspicuous feature at the sagittal line. *Marrolithoides laticirrus* differs markedly from all other species of the genus in its large, broad fringe with four, almost five concentric rows of pits in front of the glabella in the adult trilobite. Also notable is the large number of pits, including intercalated ones, in  $E_1$ . The girder of *M. orthogonius* is more strongly developed than that of *M. laticirrus*, and in this respect the latter species has a ventral aspect more reminiscent of the species of *Cryptolithus*? from the Bedinan Formation.

The French species *Trinucleus bureaui* Oehlert (1895 : 300) was described from an unspecified Ordovician horizon in Brittany. Whittard (1956 : 54) assigned *T. bureaui* to *Marrolithus* but claimed it as a composite species and drew attention to the close resemblance of some of Oehlert's illustrations to *Marrolithoides simplex* (Williams). The Breton species is in need of modern revision and, as described, may well include material attributable to both *Marrolithus* and *Marrolithoides*. Some of the specimens figured by Oehlert (e.g. 1895, pl. 1, figs. 1, 3) generally resemble *M. orthogonius* but the fringe is slightly broader anterolaterally, apparently the result of an extra concentric row of pits there, and lacks the characteristic median, triangular group of pits. The original of Oehlert's pl. 1, fig. 15 compares with a paratype of *M. orthogonius* (see Pl. 1, fig. 5) but has one more pit row and greater differentiation in pit size than the Turkish form.

### *Marrolithoides* sp.

(Pl. 4, fig. 10)

In general, *Marrolithoides* occurs in the lower part of the Bedinan Formation, not only near Sosink but also south-west of Bedinan, where it overlaps stratigraphically with *Cryptolithus*? *inferus*. The dominant trinucleid higher in the Bedinan Formation is *Cryptolithus*? *bedinanensis* but in some of the stratigraphically highest localities this is accompanied by uncommon forms which match best with *Marrolithoides*. The largest and most complete of these, It.881, is figured here from locality B.21. It has a greater number of concentric pit rows than *M. orthogonius*, and although there are four frontal rows as in *M. laticirrus* it is separated from that species by



having a straighter anterior margin and fewer, slightly larger pits in  $E_1$ , whilst the pits of  $I_2$  and  $I_3$  are almost twinned near the sagittal line.  $I_1$  is slightly raised, especially anterolaterally, and the pit-count is as follows:  $E_1$  29 or 29 estd;  $I_1$  22;  $I_2$  22:  $I_3$  22;  $I_4$  20 (from R<sub>4</sub>);  $I_5$  estd 17 or 18 from about R<sub>6</sub>;  $I_6$  estd 16 from R<sub>10</sub>. It is not evident whether  $I_7$  is represented. Fragmentary evidence of *Marrolithoides* was also obtained from locality B.18.

Genus *CRYPTOLITHUS* Green, 1832

*Cryptolithus? inferus* sp. nov.

(Pl. 2, figs. 2, 4, 6-8, 12)

DIAGNOSIS. *Cryptolithus?* with cephalon about twice as broad as long, its outline subangular anterolaterally and, occasionally, frontally. Cephalic fringe narrow (*sag.*) anteriorly with only three ( $E_1$ ,  $I_{1-2}$ ), rarely two, concentric rows of pits continuous in front of glabella.  $I_3$  generally developed from about R<sub>4</sub>. Several intercalated pits in  $E_1$ , especially frontally and anterolaterally. Pit count relatively low, as follows:  $E_1 + e_1$  27-30;  $I_1 + i_1$  22-26;  $I_2 + i_2$  21-22;  $I_3 + i_3$  19;  $I_4 + i_4$  16-17;  $I_5$  comprises about a dozen small pits in region of R<sub>10</sub> to R<sub>18</sub>;  $I_6$  not developed. Reticulation of test weak or absent in large cephalae.

HOLOTYPE. It.734 (Pl. 2, fig. 8).

PARATYPE. It.735 (Pl. 2, fig. 6).

OTHER MATERIAL. It.689 (Pl. 2, fig. 12); It.697 (Pl. 2, fig. 7); It.703 (Pl. 2, fig. 4); It.704 (Pl. 2, fig. 2).

LOCALITIES AND HORIZONS. The holotype and paratype are from locality B.1, south-west of Bedinan, where a sample of thirteen specimens was obtained from the lowest fossiliferous portion of the Bedinan Formation seen there. Another sample, also comprising thirteen specimens, from B.2, a little higher in the succession shows a pit count for  $E_1 + e_1$  which is consistently higher than that for the B.1 material (31-34 pits compared with 27-30) and is here termed *C. cf. inferus* (see below). The specimens from the two localities are otherwise indistinguishable. A single cranidium of *C.? cf. inferus* (Pl. 2, fig. 12) was found at B.3, associated with *Marrolithoides laticirrus*.

DESCRIPTION. The cephalon is about twice as broad as long, sometimes slightly broader, especially in smaller specimens, and its outline is generally well rounded except frontally, where it may be almost subangular. The glabella is high, narrow and relatively long, occupying up to five-sixths or more of the cephalic length (excluding occipital spine). It expands forwards only slightly to the rounded frontal glabellar lobe, which extends a little in front of the cheek-lobes, and the sides are bounded by almost straight axial furrows. The latter contain a pair of elongated alar lobes in immature specimens, but these structures diminished during ontogeny and are absent from the presumed adult stages. Small specimens also exhibit reticulation of the test of the cheek-lobes and centre of the glabella, but in the largest examples from the type locality this is weak or absent. On the other hand several

specimens from B.2 show stronger reticulation, but this may be no more than an accident of preservation

The cephalic fringe is only moderately broad, especially frontally but also, to a lesser degree, anterolaterally and laterally. Frontally it is constricted slightly by the extension forwards of the glabella and contains three concentric rows of pits ( $E_1$ ,  $I_{1-2}$ ).  $E_1$  extends to the genal angles and includes several intercalated pits, especially frontally but also anterolaterally and laterally. The pits of  $E_1$  decrease slightly in diameter towards the genal angles, and frontally they are of approximately similar size to those of  $I_2$ . The pits of  $I_1$  are larger than those of other rows and they, too, diminish a little anterolaterally.  $I_3$  is developed from  $R_3$  or  $R_4$ ,  $I_4$  from about  $R_9$ , and  $I_5$  from about  $R_{10}$  to  $R_{12}$ . The following pit count is based on thirteen specimens from B.1:  $E_1 + e_1$  27-30;  $I_1 + i_1$  22-26;  $I_2 + i_2$  22;  $I_3 + i_3$  19;  $I_4 + i_4$  16. In the holotype  $I_5$  consists of 12 small pits which extend from  $R_{10}$  to  $R_{17}$  or  $R_{18}$ ; the row then terminates until just in front of the posterior border furrow, where three further pits form an apparent continuation. The hindmost of these three is slightly the largest and probably represents the position of an apodeme, sited at the fulcrum and functional in the articulation of posterior border and first thoracic segment. The material available is insufficient to show whether this break in the line of  $I_5$  is a reliable specific character, but a broadly similar break was found in at least two other specimens at the type locality. A sample of thirteen specimens from B.2, some 10 m. higher in the succession (see Text-fig. 3), gave the following pit count:  $E_1 + e_1$  31-34;  $I_1 + i_1$  22-23;  $I_2 + i_2$  21-22;  $I_3 + i_3$  19 (from  $R_2$ );  $I_4 + i_4$  17 (from  $R_4$ ). Again,  $I_5$  is discontinuous, with twelve to thirteen pits anterolaterally and a further two or three near the posterior border furrow. The slightly higher number of pits in  $E_1$  is not considered to justify separation of these specimens, which are listed and figured as *Cryptolithus*? cf. *inferus* (Pl. 2, figs. 2, 4, 7). The marginal cephalic suture is of normal trinucleid type and at the genal angles the lower fringe lamella is produced posterolaterally to form a pair of librigenal spines which are long and slender, at least twice the median length of the cephalon, prismatic in cross-section, and have a longitudinal ridge continuous with the  $E_1/I_1$  girder. In addition, two pseudogirders ( $I_1/I_2$  and  $I_2/I_3$ ) are fairly well developed, particularly frontally.

The thorax consists of six segments, the first of them slightly macropleural. The axis occupies about one-quarter of the total breadth, stands a little higher than the side-lobes, and is bounded by shallow, broad axial furrows. Each segment has a small, articulating half-ring separated from the axial ring by an articulating furrow which, on the internal mould, appears deep and broad (*sag.*) with a pair of apodemes sited abaxially. The pleurae are horizontal, parallel-sided, their tips obliquely truncated to form posterolateral points. Each pleura carries a broad, shallow, pleural furrow which runs almost straight from the anterior margin, at the axial furrow, and just fails to attain the pleural tip.

The pygidium is closely similar to that found in other species of the genus, that is to say its outline is an Isosceles triangle, three and a half times as broad as long, with a transversely straight frontal margin and broadly divergent, faintly sinuous, lateral margins. The small axis occupies one-sixth of the frontal breadth, tapers

back to the tip, and is separated from the flat side-lobes by gently curved, shallow axial furrows. There are about ten axial rings, those after the sixth being less well defined. The side-lobes carry four and a half pairs of more or less well-defined pleural ribs, occasionally with traces of a fifth pair.

A discussion of *Cryptolithus? inferus* and other species of the genus follows the description of *C.? bedinanensis* (see below).

***Cryptolithus? bedinanensis* sp. nov.**

(Pl. 3, figs. 1-7, 9; Pl. 4, figs. 2-9)

DIAGNOSIS. *Cryptolithus* with cephalon (excluding librigenal spines) about twice as broad as long, its outline rounded frontally, but with sides almost straight and slightly convergent forwards. Cephalic fringe moderately broad, typically with 3 concentric rows of pits ( $E_1$ ,  $I_{1-2}$ ) in front of glabella, and traces of ridge between  $E_1$  and  $I_1$  anterolaterally.  $I_3$  well developed, and proportion of specimens with 4 rows of pits in front of glabella increases higher in stratigraphical succession.  $I_{1-2}$  pits larger than those of adjacent rows.  $E_1$  extends to genal angles and contains several intercalated pits. Pit count as follows:  $E_1$  typically 32-36 but full range 26-38;  $I_1$  21-27, mostly 23-27;  $I_2$  21-26, mostly 23-25;  $I_3$  20-25, mostly 22-25;  $I_4$  16-23, mostly 18-21;  $I_5$  10-18, mostly 14-18;  $I_6$  6-13, mostly 7-10;  $I_7$  rarely seen, with only very few pits. Thorax and pygidium of general cryptolithinid type; latter has about ten axial rings and five and a half pairs of pleural ribs.

HOLOTYPE. It. 1210 (Pl. 3, figs. 2, 3).

PARATYPES. It. 1211 (Pl. 3, fig. 6); It. 1231 (Pl. 3, fig. 9).

LOCALITIES AND HORIZONS. The lowest stratigraphical occurrence of the *forma typica* is at B.6, south-west of Bedinan, where the largest sample (29 specimens) was obtained. This is also the type locality, and the greater part of the sample showed 3 pit rows in front of the glabella, though a few had 4 rows (see Pl. 3, fig. 1). The species was found subsequently throughout the remainder of the mudstone sequence of the Bedinan Formation and the proportion of specimens with 4 frontal rows of pits increased until the ratio of the two types at B.6 was almost reversed at B.16 (for data, see below).

DESCRIPTION. The entire dorsal exoskeleton of a slightly compressed individual is a little broader than long, approximately in the ratio 7:6. Just over half the median length is occupied by the cranium, which is slightly more than twice as broad as long, the maximum breadth being measured across the genal angles. The outline is generally well rounded frontally and anterolaterally, but often straighter towards the genal angles. The glabella expands forwards gently in both height and breadth for about five-sixths of its length and then contracts to form a well-rounded frontal lobe. It is set higher than the convex cheek-lobes and is separated from them by broad, nearly straight, axial furrows. The latter become slightly broader posteriorly in the adult trilobite, and even more so in immature individuals so as to accommodate a pair of low, elongated alar lobes. As in other cryptolithinids the alar lobes became progressively smaller during ontogeny and eventually disappeared. The sides of the glabella carry two pairs of shallow impressions which represent

glabellar furrows delimiting two small pairs of almost indiscernible glabellar lobes (Pl. 3, fig. 9). A shallow occipital furrow deepens abaxially to where, as seen on the internal mould, a pair of apodemes is sited behind the outer margins of the axial furrows. The occipital ring is short (*sag.*), slopes backwards gently, and is produced to form a slim occipital spine. The quadrant-shaped cheek-lobes extend forwards as far as the line of maximum breadth of the glabella. Both they and the axial portion of the glabella, which is surmounted by a small, median tubercle, frequently carry a fine, mesh-like ornamentation of raised ridges, though this is not always preserved and may not always have persisted in large individuals. In one or two immature examples a pair of fine nervures is visible on the cheek-lobes. The posterior border furrow is transversely straight, of only moderate depth, and becomes broader (*exsag.*) abaxially; its posterior margin is more steeply inclined than the anterior. The posterior border is narrow (*exsag.*), ridge-like, transversely straight for less than half the distance from the axial furrows to the lateral margins; it then meets a pair of fulcra and flexes down and slightly backwards around relatively small posterior prolongations of the cephalic fringe. In most trinucleids the cephalic fulcra are denoted by a pair of pits, often large, in the posterior border furrow. In the case of *Cryptolithus? bedinanensis* it is not clear whether they correspond to the hindmost pits of the innermost concentric row of the fringe.

The cephalic fringe is of moderate breadth frontally, where 3 or 4 concentric rows of pits ( $E_1$  and, respectively,  $I_{1-2}$  or  $I_{1-3}$ ) are developed in front of the glabella. The fringe becomes broader anterolaterally and laterally, where additional I rows soon appear. Many specimens show a low, thin ridge on the dorsal lamella, running between  $E_1$  and  $I_1$ , and diminishing frontally and posterolaterally. It is not clear whether this was a primary structure, but such a ridge could well have been formed by dorsal compression of a fringe in which  $I_1$  was originally set slightly higher than the adjacent rows, particularly anterolaterally (see Pl. 4, fig. 6). In the case of cephalia with 3 concentric pit rows at the sagittal line, the pitted area is invaded to a greater degree by the front of the glabella, and it was thought at first that there were grounds for separating such forms from others possessing 4 complete frontal rows and little extension forwards of the glabella. All now appear to fall within the limits of variation for the species but the proportion of specimens with 4 rows (even in small cephalia) increases as one ascends the succession, as shown below.

| Locality | Sample | No. with 3<br>frontal rows | No. with 4<br>frontal rows |
|----------|--------|----------------------------|----------------------------|
| B.6      | 29     | 18                         | 2 or 3                     |
| B.8      | 6      | 1                          | 2                          |
| B.9      | 1      | —                          | 1                          |
| B.10     | 4      | 2                          | 1                          |
| B.11     | 2      | —                          | 1                          |
| B.12     | 6      | 4                          | 2                          |
| B.13     | 13     | 3                          | 6                          |
| B.14     | 3      | 1                          | 1                          |
| B.15     | 11     | 2                          | 5                          |
| B.16     | 16     | 2                          | 12                         |
| B.20     | 1      | —                          | —                          |
| B.22     | 4      | —                          | 1                          |



When three frontal rows of pits are present the succeeding row,  $I_3$ , is always well developed and may extend as far forwards as  $R_3$  or  $R_4$ . Of the remaining rows,  $I_4$  extends from  $R_5$  or  $R_6$  (occasionally  $R_8$  or  $R_9$ ),  $I_5$  from  $R_7$  to  $R_9$  (less commonly  $R_9$  to  $R_{15}$ ), whilst  $I_6$ , although not always present in immature cephalata, is usually found as far forwards as  $R_{12}$  to  $R_{15}$ .  $I_7$  is represented in only two specimens, from B.13 and B.16, by five small pits along the anterolateral boundary of each cheek-lobe. There is only one E row, extending to the genal angles and composed of numerous pits which greatly outnumber those of the I rows and are correspondingly more difficult to fit into a radial pattern. The I rows exhibit a strong radial arrangement which persists to within a few (generally 3 or 4) pits of the posterior border; usually there are 17 to 21 radii, though occasionally up to 23 in individuals with a particularly high overall pit-count. The pits of  $I_1$  and  $I_2$  are of about equal size, somewhat larger than those of  $E_1$  and  $E_2$  which are also about equisized; the pits of the remaining rows become smaller from  $I_4$  to  $I_6$ . There are occasional deviations from this general rule and the pits of  $E_1$  are sometimes slightly smaller than those of  $I_3$ . The following table shows the variation in the number of pits present in individual concentric rows on the cephalic fringe of *Cryptolithus? bedinanensis*. A blank indicates that the material available was insufficiently well-preserved to obtain a reliable figure. At B.6 and B.13 the wide range of variation is accounted for by small cephalata with a lower pit-count.

| Locality | No. in sample | $E_1 + e_1$            | $I_1 + i_1$            | $I_2 + i_2$            | $I_3 + i_3$            | $I_4 + i_4$ | $I_5 + i_5$ | $I_6 + i_6$ | $I_7$                        |
|----------|---------------|------------------------|------------------------|------------------------|------------------------|-------------|-------------|-------------|------------------------------|
| B.6      | 29            | 26-36<br>esp.<br>34-36 | 23-27                  | 21-26<br>esp.<br>23-25 | 21-25<br>esp.<br>23-25 | 16-19       | 10-14       | c. 6-8      | —                            |
| B.8      | 6             | 27-31                  | 21                     | 22                     | 22-23                  | 18-19       | —           | c. 10       | —                            |
| B.9      | 1             | 29                     | c. 22                  | —                      | —                      | —           | —           | —           | —                            |
| B.10     | 4             | 28-33                  | 22-24                  | 21-23                  | 22                     | 18          | 17          | c. 10       | —                            |
| B.11     | 2             | 33                     | 23                     | c. 24                  | c. 21                  | —           | —           | —           | —                            |
| B.12     | 6             | 29-35                  | 25-26                  | 24-26                  | 22-25                  | 13-18       | c. 17       | c. 7        | —                            |
| B.13     | 13            | 29-38<br>esp.<br>33-38 | 21-27<br>esp.<br>23-27 | 21-26<br>esp.<br>24-26 | 22-25                  | 18-23       | 17-18       | 6-7         | 5 pits<br>in one<br>specimen |
| B.14     | 3             | 32-34                  | 23-24                  | 23-25                  | 20                     | —           | —           | —           | —                            |
| B.15     | 11            | 32-35                  | 23-25                  | 23-25                  | 22-25                  | 20-21       | 16-18       | —           | —                            |
| B.16     | 16            | 31-38                  | 22-26                  | 22-26                  | 22-25                  | 20-21       | c. 16       | 5-6         | 5 pits<br>in one<br>specimen |
| B.20     | 1             | —                      | c. 24                  | —                      | c. 20                  | —           | —           | —           | —                            |
| B.22     | 4             | 31                     | c. 23                  | c. 23                  | 23                     | 20-21       | c. 16       | 12-13       | —                            |

On the ventral lamella of the cephalic fringe each genal angle is produced posterolaterally to form a long, slim, gently-curved librigenal spine. Each spine is prismatic in cross-section with longitudinal ridges, the lower of which extends a little way into the pitted area of the fringe and then bifurcates. Of the branches so formed, one is developed as a thin, sharp ridge, the true girder, between  $E_1$  and  $I_1$ ; the other

forms a slightly broader but lower ridge, the  $I_1/I_2$  pseudogirder. A further pseudogirder is developed between  $I_2$  and  $I_3$  both frontally and anterolaterally, where it attains approximately the same dimensions as the  $I_1/I_2$  pseudogirder. These structures are shown clearly in Pl. 3, fig. 7.

A few immature specimens of *Cryptolithus?* were collected from the Bedinan Formation and one of the smallest and best preserved is shown in Pl. 3, fig. 8. It exhibits the features characteristic of a trinucleid *Meraspis*, including genal angles set in front of the line of the posterior border furrow, and well-developed alar lobes. The fringe is narrow, consisting almost solely of two concentric pit rows, but the count of 23 pits is high.

The thorax consists of six segments, the first one macropleural, and is indistinguishable from other members of the genus. Material from the type locality shows clearly that the pleural tips are blunt, almost vertical, and form a virtual continuation of the form of the anterolateral margins of the pygidium (see Pl. 3, fig. 2).

The pygidium is also of the form characteristic for the genus, with a low, narrow, marginal rim. The margin is moderately declined over the median third but becomes vertical anterolaterally (see above). In apparently adult examples the axis has the first four rings well defined, with only traces of a further six rings. Small specimens generally have better-defined axial rings which appear confluent with the pleural ribs (for example Pl. 3, fig. 6, probably *Meraspis*, Degree 5). The side-lobes carry about five and a half pairs of ribs, separated by broad (*exsag.*), shallow, pleural furrows which broaden towards the margin.

A cranium of unusual type (Pl. 2, fig. 10) was found at locality B.6 in association with *Cryptolithus? bedinanensis*. It differs from the latter in having a particularly short glabella and lateral margins which, judging from the incomplete material, must have been slightly divergent forwards. The specimen is apparently malformed and therefore difficult to compare with other species. The concentric arrangement of pits is relatively irregular frontally, where  $I_2$  is of normal type,  $I_1$  is deflected slightly inwards, and  $E_1$  is displaced markedly inwards from the margin. Consequently several pits, estimated as 6 or 7 on the complete cephalon, are arranged in interradian positions frontally, almost as an incipient  $E_2$ . The specimen is listed merely as *Cryptolithus? sp.*

Another example of a pathological cranium was found at B.13 and is figured as *Cryptolithus? cf. bedinanensis* (Pl. 4, fig. 1). The left side generally resembles that species but on the right side  $E_1$  does not extend as far forwards as the axial furrow, whilst  $I_1$  and  $I_2$  become irregular and flex forwards, the former row reaching the cranial margin in front of the right axial furrow.

DISCUSSION. All the species of *Cryptolithus* described by Whittard (1958: 72 *et seq.*) from the Shelve Inlier were obtained from strata of the Llanvirn and Llandeilo Series and so are considerably older than the Turkish specimens. The Anglo-Welsh forms possess cheek lobes which are relatively large and extend forwards level with the front of the glabella, whereas in the Turkish material the glabella invariably extends beyond the cheek-lobes and often invades the pitted fringe area, to be accommodated by a flexing forwards of the inner concentric rows of pits. Another conspicuous point of difference is that the Anglo-Welsh specimens

exhibit an unusually large range of pit size, those of the inner and posterolateral parts of the fringe being often exceedingly small; The Turkish specimens have the pits of  $I_1$  and  $I_2$  of approximately similar size, whilst the pits of all the other rows, although smaller, are never minute. An exception to these generalizations is offered by the cephalon of "*Cryptolithus* sp." figured by Whittard (1956, pl. 9, fig. 16) from the Lower Llanvirn of the Llandrindod area of Wales. In this form the pits are both fewer and of simpler disposition, features more reminiscent of the North American species of the genus, but only one example is yet known. Some of the specimens figured by Whittard have relatively large pygidia and in one individual (Whittard 1956, pl. 10, fig. 5) referred to *Cryptolithus* cf. *inopinatus* the pygidium seems atypical of that genus but strongly suggestive of *Lloydolithus*. It is, of course, possible that groups of trinucleids with rounded cephalic outline and one row of pits external to the girder arose independently from different genera, and may also have been differentiated geographically, but the evidence is not conclusive.

A feature of all the specimens of *Cryptolithus*? from the Bedinan Formation is the development of  $E_1$  as a row of numerous small pits extending to the genal angle. This is reminiscent of the dorsal aspect of the cephalic fringe in *Onnia* Bancroft from the higher Caradoc Series of South Shropshire (for discussion see Dean 1960: 127), but in the latter case the pits of  $E_1$  and  $I_1$  are larger than, and raised above, those of adjacent rows, whilst radial sulci are well developed from  $I_2$  inwards. The ventral fringe surface of *Onnia* is particularly distinctive, having a strong girder with two concentric rows of pits ( $E_{1-2}$ ) external to it. The girder itself is continuous with a ridge along the librigenal spine and there is a lesser development of pseudogirders between concentric rows internal to the girder, the  $I_1/I_2$  pseudogirder at least arising from a subsidiary branch of the main structure of ridge and girder. A somewhat similar condition is found in the Turkish specimens but with only a single E row developed. In addition some examples have the girder more weakly developed so that it appears scarcely more prominent than the adjacent pseudogirders.

*Cryptolithus*? *inferus* shows only relatively small differences from the majority of the stratigraphically earlier members (including the types) of *C.*? *bedinanensis*, that is to say specimens which also have three concentric rows of pits in front of the glabella. *C.*? *inferus* typically has a much lower  $E_1 + e_1$  count; there is one fewer I row (this is particularly noticeable anterolaterally, where the fringe is narrower); and the anterior portion of  $E_1$  consists of slightly larger pits with fewer intercalated pits.

One can postulate an evolutionary sequence within the members of *Cryptolithus*? in the Bedinan Formation. The earliest representatives, typical *C.*? *inferus*, soon acquire a slightly higher number of pits in  $E_1$  (the latter specimens are denoted as *C.*? cf. *inferus*). Higher in the succession appears *C.*? *bedinanensis* which could have developed from *C.*? *inferus* by the addition of extra pits in almost all rows, and one concentric row internal to the girder. Further increase in the pits of  $I_3$  led to the formation of four frontal rows in the majority of later members of the species, though the average count for individual rows does not apparently show any significant increase.

Judging from the marked Bohemian affinities of the remainder of the fauna, one

might expect to compare the Bedinan trinucleids with those of Bohemia, but the lack of relevant literature makes this difficult. Whittington (1940) considered the Czech species *Trinucleus ornatus* Sternberg, *T. goldfussi* Barrande and *T. ultimus* Barrande to be identical, and redescribed them as *Onnia ornatus* (Sternberg). The type material of all these species comes from different stratigraphical horizons and Marek (1952 : 23) has pointed out that *Trinucleus ultimus*, at least, merits specific separation. Of the material illustrated by Whittington, his pl. 3, fig. 6 bears some resemblance to *Cryptolithus? bedinanensis* with three frontal pit rows (this paper, Pl. 3, fig. 3), but the pits of the outermost row seem fewer and rather more regularly arranged in the Czech specimen. The ventral fringe surface illustrated by Whittington (1940, pl. 3, fig. 5) shows a girder and pseudogirders which are perhaps more like those of the Turkish specimens than in *Onnia* (s.s.). The original of Whittington's pl. 3, fig. 6 was said to have been labelled as *Trinucleus goldfussi* by Barrande, and the preservation in a fine-grained, buff sandstone (Whittington 1940 : 243) suggests a possible origin in the Letná Beds of the Caradoc Series. The specimen, a cranidium, has four frontal, concentric rows of pits, several rows anterolaterally, and the lateral margins are slightly divergent forwards. The outline is reminiscent of some examples of *Marrolithoides laticirrus*, but the latter has a much larger number of pits in the outermost concentric row. Further discussion of these problems must await a modern revision of the Bohemian trinucleids.

Family **DIONIDIDAE** Gürich, 1907

Genus **DIONIDE** Barrande, 1847

***Dionide formosa*** (Barrande) ***anatolica*** subsp. nov.

(Pl. 5, figs. 1-4, 6, 7, 12)

DIAGNOSIS. Subspecies of *Dionide formosa* distinguished by following features : cephalic fringe longer (sag.) in front of glabella, with less well-developed marginal row of fringe-pits ; genal angles turned backwards less strongly ; pygidium proportionately shorter with slightly narrower axis, eleven to thirteen axial rings, and ten to twelve pairs pleural ribs.

HOLOTYPE. It. 1061 (Pl. 5, figs. 1, 2).

PARATYPES. It. 1057 (Pl. 5, fig. 12) ; It. 1062 (Pl. 5, fig. 6) ; It. 1063 (Pl. 5, fig. 7) ; It. 1178 (Pl. 5, fig. 4) ; It. 1201 (Pl. 5, fig. 3).

HORIZONS AND LOCALITIES. All the type material is from the section near Ziyaret, east of Sosink, the holotype being collected from locality A.3 and the paratypes from A.3, A.5 and A.6. All these localities are believed to be in the lower part of the Bedinan Formation.

DESCRIPTION. The cephalon, excluding librigenal spines, is transversely almost semielliptical in plan ; the median length varies from just over one-third to almost a half of the maximum breadth, according to the degree of crushing of the specimens. The tumid glabella is roughly subquadrate in outline, the frontal lobe rounded,



convex forwards and bounded by a narrow (*sag.*), deep preglabellar furrow. The posterolateral portions of the glabella are formed by a pair of large lobes, almost reniform in plan, which project slightly beyond the lateral margins of the glabella and are set below the level of the median body. They are defined by a pair of broad, shallow furrows which deepen posteriorly. One specimen (Pl. 5, fig. 4) shows the hindmost part of the glabella forming a depressed, neck-like structure, its anterior boundary immediately behind the posterior ends of the lateral lobes. As all the material is crushed, it is not clear whether this structure is primary. A narrow occipital furrow separates the glabella from a small, occipital ring which becomes shorter (*exsag.*) towards the axial furrows. Deep axial furrows separate the glabella from cheek-lobes which are almost quadrant-shaped, slightly broader than long. The cranidium is circumscribed by a narrow, low, marginal rim which is ridge-like frontally but becomes slightly broader and less inclined posterolaterally. Internal to the rim is a pitted fringe of the type characteristic for the genus, and this attains a breadth (*sag.*) frontally of between one-quarter and one-third of the length of the glabella; this refers, of course, to compressed material and takes no account of any original inclination of the fringe. Laterally the line of demarcation between the fringe and cheek-lobes is difficult to distinguish, owing to crushing and the fact that both carry similar ornamentation. A comparable state of affairs was noted by Whittard (1958: 99) when redescribing *Dionide jubata* Raymond. The cheek-lobes are separated by a broad (*exsag.*), posterior border furrow from a posterior border which is at first transversely straight and almost uniformly broad but then becomes narrower, turns back slightly, and finally coalesces with the hindmost, less inclined parts of the marginal rim described earlier. The surface of each cheek-lobe is traversed by a conspicuous, branched nervure which runs posterolaterally from the axial furrow, opposite the centre of the glabella, towards the genal angle. The nervure comprises thickened, irregular ridges whose development is somewhat variable. In two cases (Pl. 5, figs. 4, 6) each nervure includes two branches which coalesce near the genal angle and then die out quickly. In another (Pl. 5, fig. 3) only a single ridge is visible, whilst the holotype (Pl. 5, figs. 1, 2) shows a third, smaller branch in front of the main pair, the anterior of which is slightly the thicker. The glabella is surmounted by a conspicuous median spine, rounded in cross-section and directed backwards and slightly upwards. In the somewhat crushed holotype the length of the spine approximates to that of the cranidium, but it was probably even longer originally. A similar structure in *Dionide formosa* was illustrated by Hawle & Corda (1847, pl. 3, fig. 16) but is not usually preserved. More recently, however, Curtis (1961: 14) has noted a Portuguese example with the spine at least 5 mm. long. One specimen from the Bedinan Formation shows the left librigena (Pl. 5, fig. 3) which, although damaged, is seen to end in a long, curved librigenal spine, the original length of which is estimated to have been at least twice that of the cephalon.

A complete thorax has not been found but one incomplete specimen (Pl. 5, fig. 3) shows four segments, the first of them markedly macropleural. Another (Pl. 5, fig. 7), with pygidium attached, has five equisized segments and is also incomplete as it lacks a macropleural segment. It is reasonable to assume that six segments

would normally be present, the customary complement for the genus. The axis occupies just over one-fifth of the thoracic breadth, stands only a little higher than the side-lobes, and is bounded by narrow, almost straight, axial furrows which converge gently backwards. Each axial ring is almost rectangular in plan but ends anterolaterally in a well-defined pair of subtriangular axial lobes which are more conspicuous on the internal mould. The pleurae are transversely straight, parallel-sided, and terminate in blunt points directed posterolaterally. The breadth (*exsag.*) of the pleurae of the first, macropleural segment is about one-third that of the remaining segments. A pleural furrow runs from the anterior edge of each pleura immediately outside the axial furrow. At first it is deep and narrow, and runs almost to the centre of the pleura in a broad curve, concave forwards; it then becomes broader (*exsag.*) and shallower, and runs backwards very slightly, sub-parallel to the anterior margin, almost to the pleural tip, where it turns back more strongly and dies out. In the case of the macropleural first segment the pleural furrows are directed backwards more strongly, and the inner part of the anterior band (Pl. 5, fig. 3) is inflated, as in *Dionide formosa formosa* (see Whittington 1952, Text-fig. 1).

The best-preserved pygidium (Pl. 5, fig. 7) is slightly more than three times as broad as long, sub-semielliptical in outline with the anterior margin almost transversely straight. Another specimen (Pl. 5, fig. 12) appears to be proportionately longer but is more compressed. The axis, which occupies just over one-sixth of the frontal breadth, has the outline of an isosceles triangle, with well-defined straight sides converging backwards at about  $20^{\circ}$ . There are at least eleven axial rings on the first specimen, thirteen on the other, and the axis ends in a very small terminal piece just short of the posterior margin. The side-lobes have an almost flat surface which apparently becomes slightly declined near the pygidial margin, and they carry from ten to twelve pairs of pleural ribs in addition to the pair of anterior half-ribs. The well-defined pleural furrows become progressively more strongly directed backwards towards the rear of the pygidium. They are narrow and almost straight over most of their length (*tr.*) but within a short distance of the margin they turn backwards and die out, apparently without attaining the margin, so that a narrow, smooth border results. In a few cases the furrows appear to intersect the margin, but this may be due to crushing. Faint interpleural furrows are visible on the adaxial portions of the first five or so ribs but become obsolete on the remaining ribs.

DISCUSSION. Many of the various species of *Dionide* have been enumerated and discussed during recent years by both Whittington (1952) and Whittard (1958). The Turkish specimens bear an overall resemblance to *Dionide formosa* (Barrande) and are probably of broadly similar age, but there are sufficient minor differences to warrant their separation as a new subspecies. First, the cranidium of *D. formosa formosa* has longer posterolateral genal prolongations, whilst the cephalic fringe contains a more conspicuous zone of marginal pits, larger and slightly more widely-spaced than those of *D. formosa anatolica*. Second, although the nervures of the two forms are of similar type those of the Turkish subspecies are apparently less strongly developed (judging from Whittington's illustrations, 1952, pl. 1, figs. 1, 2,

5) whilst one specimen shows an additional branch. Third, the pygidium of *D. formosa anatolica* is better segmented, with a greater number of both axial rings and pleural furrows. The conspicuous nervures of *D. formosa anatolica* easily distinguish the new subspecies from forms such as *D. jubata* Raymond (of Llanvirn age) and *D. euglypta* (Angelin) var. *quadrata* Whittard (of Caradoc age; see Whittard 1958 : 99-102). *Dionide atra* Salter may also be of Caradoc age but has an unusually and distinctively large number of axial rings and pleural ribs (Whittard 1959 : 98). *Dionide turbulli* Whittington (1952 : 8), from the Llanvirn Series, differs from *D. formosa anatolica* in having a much broader cephalic fringe with radiating ridges, very long genal prolongations, and a pair of strongly-developed, single nervures. *Dionide hybrida* Reed (1915 : 26, pl. 5, fig. 7), from the Hwe Mawng Beds of Burma (exact age uncertain), has a cephalic outline similar to that of *D. formosa anatolica* but the glabella, which carries a median tubercle, is relatively larger, whilst the fringe is narrower and has coarser pitting, especially marginally where there is a conspicuous row of large pits. No nervures are visible in Reed's illustrations or noted in his description, but the species is founded on only a single, abraded specimen. *Dionide asiatica*, from the Ordovician of Eastern Yunnan, was founded by Kobayashi (1940 : 205) on the specimen figured by Mansuy (1912 : 37, pl. 6, figs. 2a, b) as *D. formosa*. Though broadly similar to *D. formosa formosa* and *D. formosa anatolica*, Mansuy's specimen may be distinguished by the following features : the nervures are less strongly developed ; the frontal part of the cephalic fringe is much narrower (*sag.*) ; there is a marginal row of conspicuously large fringe pits ; the pygidium is relatively longer and better segmented with twenty-five axial rings and about sixteen or seventeen pairs of pleural ribs in addition to the anterior pair of half-ribs.

### Family DALMANITIDAE Vogdes, 1890

#### Genus DALMANITINA Reed, 1905

#### *Dalmanitina proaeva proaeva* (Emmrich)

(Pl. 6, figs. 1-9, 11-13 ; Pl. 7, figs. 4, 5)

1839 *Phacops proaevus* Emmrich : 25.

1956 *Dalmanitina proaeva proaeva* (Emmrich) Šnajdr : 513, pl. 4, figs. 10, 11 ; pl. 5, fig. 4. Includes discussion of species.

The species and subspecies of *Dalmanitina* in the Caradoc and Ashgill Series of Bohemia have been revised by Šnajdr (1956). They comprise, in ascending stratigraphical order : *D. proaeva cilinensis* Šnajdr, Drabov Beds ; *D. proaeva socialis* (Barrande), Letná Beds ; *D. proaeva proaeva* (Emmrich) [Šnajdr lists this only from the Chlustina Beds but Havlíček and others (1958) record it also from the underlying Černín Beds] ; and *D. proaeva grandis* (Barrande), Králův Dvůr Beds.

Three pygidia of *D. proaeva proaeva* from the Chlustina Beds, figured by Šnajdr, exhibit a small amount of variation. One (Šnajdr 1956, pl. 4, fig. 10) has ten axial rings and seven and a half pleural ribs ; another (pl. 4, fig. 11) shows nine axial rings and seven and a half pleural ribs ; whilst the third (pl. 5, fig. 4) has nine axial rings and eight and a half pleural ribs, as far as can be judged. There is a strong overall

resemblance to the pygidium of *D. proaeva socialis* but the latter, while possessing a similar number of pleural ribs, has deep, relatively broad (*exsag.*) interpleural furrows, whereas those of *D. proaeva proaeva*, although distinct, are narrow and shallow.

Remains of *Dalmanitina* were found, in varying concentrations, throughout most of the Bedinan Formation, but although a certain amount of variation was observed it has proved insufficient to demonstrate the presence of more than one form. The hindmost axial rings and pleural ribs of some pygidia are not well defined but in general the range of variation is limited. The number of axial rings ranges from eight to ten (rarely traces of an eleventh), and of pleural ribs, from seven and a half to eight and a half (very rarely six, in imperfect material), figures which accord well with those for *D. proaeva proaeva*. The specimens all exhibit the broad pleural furrows and narrow interpleural furrows of the Czech species, and there are insufficient grounds for separating the two. Many of the Bedinan pygidia end in a terminal spine of varying length, usually short on the internal mould, owing to partial infilling of the internal cavity, but sometimes considerably longer on the external mould. Most of the best-preserved specimens have the spine about as long as the remainder of the pygidium, but one is exceptional in being almost one-and-a-half times as long (Pl. 7, fig. 5). The specimens are identical in all other respects.

The cephalae of both *D. proaeva proaeva* and *D. proaeva socialis* are virtually identical, and are closely matched by the Turkish specimens. Two hypostomas were collected (see Pl. 6, figs. 7, 9) and although slightly compressed (one more so than the other) they resemble that of *D. proaeva socialis* illustrated by Barrande (1852, pl. 26, fig. 21).

LOCALITIES AND HORIZONS. *Dalmanitina proaeva proaeva* was found in moderate numbers in the lower part of the Bedinan Formation as seen to the east of Sosink. The lowest record was from locality A. 1, but the species proved more abundant higher in the succession and was found at A. 2-6, especially A. 3. In the Bedinan district, presumably higher in the succession, *D. proaeva proaeva* was collected from many of the localities examined but occurred in greatest abundance in the upper part of the exposed section, covered by localities B. 17-21.

Genus **KLOUCEKIA** Delo, 1935

*Kloucekia phillipsii* (Barrande) *euroa* subsp. nov.

(Pl. 6, fig. 10; Pl. 7, figs. 1-3, 6, 7, 9, 12)

DIAGNOSIS. Subspecies of *Kloucekia phillipsii* distinguished principally by the pygidium, which has eight or nine axial rings and usually five or six pairs of pleural ribs, the latter separated from each other by deep pleural furrows carrying moderately-impressed interpleural furrows.

HOLOTYPE. It. 1188 (Pl. 6, fig. 10; Pl. 7, figs. 9, 12).

PARATYPES. It. 1187 (Pl. 7, figs. 6, 7); It. 1189 (Pl. 7, fig. 3); It. 1223 (Pl. 7, fig. 2); It. 1225 (Pl. 7, fig. 1).

LOCALITIES AND HORIZONS. *K. phillipsii euroa* is one of the most abundant and characteristic trilobites of the Bedinan Formation in the Bedinan district, where it



was collected from all but the lowest strata. It was not found in the Bedinan Formation east of Sosink, probably because the beds there are stratigraphically lower than those near Bedinan.

**DESCRIPTION.** The type species of *Kloucekia*, *Phacops phillipsii* Barrande (1846 : 27 ; 1852 : 557, pl. 22, figs. 1, 2, pl. 26, figs. 31-36), has recently been redescribed by Whittington (1962 : 7, text-fig. 2a-1) using specimens named originally by Barrande. Most of these came from Zahoržany, Bohemia, in strata once known as the Zahoržany Beds but which would nowadays be termed the Chlustina Beds, of fairly high Caradoc age. From a study of Whittington's illustrations it is clear that there are many points of resemblance between the Czech and Turkish specimens, and it has not proved possible to make a satisfactory differentiation on the basis of the cephalon and thorax. In certain cephalons from the Bedinan district the glabellar furrows appear to run backwards from the axial furrows a little more strongly than do those of *K. phillipsii*, but this could easily be accounted for by variation in preservation. Some of the Turkish specimens (see especially Pl. 7, fig. 2) have a V-shaped group of tubercles on the median portion of the frontal glabellar lobe ; such a feature, though not uncommon in numerous phacopid and dalmanitid genera, is not always preserved. One of Whittington's photographs (1962, text-fig. 2h) shows that the cephalic doublure of *K. phillipsii* possesses a vincular furrow, and a similar structure is found in *K. phillipsii euroa* (see Pl. 7, fig. 7), though perhaps a little more strongly developed.

The most obvious differences between the two forms are to be found in the pygidium. That of *K. phillipsii* has three well-defined axial rings, followed by two fainter rings and a small terminal piece, whilst the side-lobes have four pairs of deep pleural furrows, the ribs so-formed carrying faint interpleural furrows. The pygidial axis of *K. phillipsii euroa* has five, occasionally six, well-defined axial rings, followed by three less well-defined rings (the last two ring furrows do not cross the sagittal line), and ends in a very small terminal piece. The side-lobes of the Turkish subspecies usually carry five pairs of deep pleural furrows, though sometimes there are six or, more rarely, seven pairs. Five well-developed pairs of interpleural furrows are present, which cross and indent the otherwise almost smooth, gently concave border, and there is usually a trace of a sixth pair. In general the pygidium appears to be proportionately broader than that of *K. phillipsii*, but it would be unwise to assume that this is the case when the material is usually somewhat compressed. According to Šnajdr (1956 : 39) the vertical range of *K. phillipsii* in Bohemia is from the Drabov Beds to the Chlustina Beds of the Caradoc Series, but the range of *K. phillipsii euroa* may be more restricted as it has not been found in the lowest part of the Bedinan Formation, nor has it yet been recorded outside Turkey.

#### Family **CHEIRURIDAE** Salter, 1864

##### **Cheirurid** gen. et. sp. ind.

(Pl. 10, fig. 3)

An incomplete thoracic segment, figured here as a latex cast, is the only representative of the cheirurids so far found in the Bedinan Formation. The specimen shows

part of the axial ring, bearing a small axial lobe, delimited by an axial furrow which is shallow medially and deepens to both front and back. The pleura is parallel-sided for most of its length (*tr.*) and curves backwards, at first only gently and then more strongly, to end in a long, pointed tip, directed posterolaterally. The posterior margin has a small posterior flange, the outer part of which is not preserved, whilst an anterior flange of generally similar size expands conspicuously towards the fulcrum, where it ends in a projecting, articulating process. A shallow pleural furrow divides the pleura into two subequal bands, the anterior of which is slightly the narrower (*exsag.*). Along the pleural furrow is distributed a somewhat irregular row of almost equisized pits which begins just outside the axial furrow and ends without quite reaching the fulcrum. The material is insufficient for firm identification, but similar characters are to be seen in the thorax of *Placoparina*, a genus of Llanvirn-Llandeilo age (see Whittard 1958 : 112).

LOCALITY AND HORIZON. B.12, to the west of Bedinan, in the upper part of the Bedinan Formation exposed in the section there.

Family **SYNHOMALONOTIDAE** Kobayashi, 1963

Genus **NESEURETUS** Hicks, 1876

Subgenus **NESEURETINUS** nov.

TYPE SPECIES. *N. (Neseuretinus) turcicus* sp. nov.

DIAGNOSIS. Subgenus of *Neseuretus* distinguished by large, inclined, anterior border, with convex, transversely straight, preglabellar field delimited by conspicuous preglabellar and anterior border furrows.

DISTRIBUTION. South-eastern Turkey, Burma and southern China.

***Neseuretus (Neseuretinus) turcicus*** sp. nov.

(?Pl. 7, figs. 8, 10, 11; Pl. 9, figs. 1-4)

DIAGNOSIS. As for subgenus.

HOLOTYPE. It. 1179 (Pl. 9, figs. 1-3).

PARATYPE. It. 1205 (Pl. 9, fig. 4).

LOCALITY AND HORIZON. The species is known with certainty from only locality B.2 at the section south-west of Bedinan, where it occurs in the lower part of the Bedinan Formation. A pygidium tentatively referred to the new form (see Pl. 7, figs. 8, 10, 11) was recovered from a probably similar horizon at locality A.3, east of Sosink.

DESCRIPTION. The species is represented by two incomplete cranidia preserved as internal and external moulds. The cranidium is moderately convex both longitudinally and transversely, with median length estimated as being slightly more than half the maximum breadth. The glabella is fairly convex, especially transversely, trapezoidal in outline, narrowing forwards so that the frontal breadth is a little more than half the basal breadth. There are four pairs of unequal

glabellar lobes, diminishing in size from back to front of the glabella. The fourth lobes are the largest, their length about one-third that of the glabella, and subcircular in outline, becoming subangular anterolaterally. The fourth glabellar furrows are deeply incised, running straight inwards and slightly backwards from the axial furrows for more than half their length (*tr.*) but then turning more sharply backwards and terminating so as to leave a pair of "necks" connecting the basal lobes to the median body. There is no obvious bifurcation of the basal furrows but at their midpoints they become notably broader, with the adaxial margins steeply bevelled. The third glabellar lobes are transversely subrectangular in plan, their long axes strongly divergent forwards, and they are bounded by parallel, well-defined third glabellar furrows which are deepest adaxially. The second glabellar lobes are generally similar to, though smaller than, the third pair, but expand slightly at their outer ends, the second glabellar furrows becoming correspondingly less divergent forwards. The second, third and fourth pairs of furrows end adaxially in-line so as to leave a smooth median body which is almost parallel-sided and occupied just less than one-third of the basal glabellar breadth. Immediately in front of the second glabellar lobes the glabella narrows slightly, forming a small "step" in the outline. The first glabellar lobes are very small, about half the length (*exsag.*) of the first pair, and poorly defined frontally by first glabellar furrows which are little more than inconspicuous, shallow notches. The frontal glabellar lobe is very short, and the almost straight anterior margin has a shallow median indentation. The length (*exsag.*) of the frontal lobe diminishes markedly towards the posterolateral angles, which are less well defined than the remainder of the lobe and appear to extend abaxially just beyond the first glabellar lobes. The axial furrows are deep and broad, converging forwards in straight lines as far as the second glabellar furrows, beyond which they become more diffuse, meeting the well-defined preglabellar furrow and "anterior furrows" (see later) at a pair of broad depressions in which a pair of hypostomal pits is sited approximately opposite the mid-point of the frontal glabellar lobe. The distance from the front of the glabella to the anterior margin of the cranidium is estimated to be a little more than two-thirds of the glabellar length, that is to say it is unusually long for the genus, and is composed of two distinct parts, an anterior border and what appears to be a true preglabellar field. The anterior border is relatively large, longest (*sag.*) medially but shortening abaxially, strongly arched transversely, and fairly steeply inclined forwards to form a scoop-like front to the cranidium. The preglabellar field is well developed, its surface strongly convex, standing slightly higher than the front of the glabella. In plan it is transversely subrectangular, defined posteriorly by the almost straight preglabellar furrow and anteriorly by a deep, broad (*sag.*), anterior border furrow which is well-rounded in cross-section. The outer ends of the preglabellar field are truncated by broad (*tr.*), moderately-deep furrows which form forwards extensions of the axial furrows. Whittard (1960:143) introduced the term "anterior furrows" for apparently similar structures seen in other species of *Neseuretus*, defining what he described as the "anterior area", believed by him to represent the combined anterior border and preglabellar field. In the new species there can be little doubt that a true preglabellar field is present, so that the furrows truncating it laterally are

equivalent to the posterior portion of Whittard's anterior furrows. The palpebral lobes are sited opposite the second glabellar lobes and the third glabellar furrows. They are unfurrowed, strongly convex outwards in plan, stand a little lower than the adjacent parts of the glabella, and have their surface gently declined adaxially. The fixigenae are convex, arching downwards to both front and rear from the vicinity of the palpebral lobes. The gonatoparian facial suture is of the type characteristic for the genus. The surface of the test is incompletely known, but that of the anterior border is finely granulated, whilst the glabellar lobes, median body and preglabellar field carry coarser tubercles.

The remainder of the exoskeleton is unknown with certainty but a single, incomplete pygidium of appropriate type from near Sosink is referred questionably to the new species (Pl. 7, figs. 8, 10, 11). The specimen has undergone slight compression but is not unduly distorted. The axis extends to, or almost to, the tip of the pygidium and its frontal breadth is just over one third of the total breadth, which is measured just in front of centre. In addition to the articulating half-ring there are seven well-defined axial rings, followed by two less distinct rings (as far as can be judged) and a small terminal piece. The ring furrows all deepen abaxially and there is a break in the outline of the axis behind the fifth axial ring; as far as this point the deep axial furrows converge backwards at about thirty degrees, but beyond it, to the blunt tip, they are subparallel. The side-lobes are arched-down moderately and each carries five deep pleural furrows and a sixth, fainter furrow. The anterior half-rib is deflected ventrally to form a facet of only moderate size. Each of the remaining ribs carries an interpleural furrow which is only faint over most of its length (*tr.*) but then forms a broad depression level with the abaxial ends of the adjacent pleural furrows and is directed obliquely backwards and outwards in relation to them. Although the specimen is incomplete there appears to be a smooth, narrow border.

**DISCUSSION.** Numerous species of *Neseuretus* have been described, mostly from the Arenig and Llanvirn Series, and many of them have been discussed by Whittard (1960: 138-151). Almost all can be separated from the new species by their possession of a so-called "anterior boss" in front of the glabella and their lack of a discrete preglabellar field, the only form possessing an apparently similar structure being *Neseuretus birmanicus* (Reed), a species now assigned to *N. (Neseuretinus)*. This form was described from the Upper Naungkangyi Beds of Burma as *Calymene birmanica* by Reed (1906: 71, pl. 5, fig. 27; 1915: 44, pl. 8, figs. 1-5), and although there is still uncertainty regarding the precise geological age it may not be far removed from that of the new Turkish species. More recently Lu (1957: 288, pl. 154, figs. 1, 2) has figured as *Synhomalonatus* (sic) *birmanica* a cranidium and pygidium from the "Middle Ordovician" of Yunnan. His illustrations are merely reproductions of two of Reed's figures of 1915, but the record is interesting in that it extends the known geographical range of *Neseuretinus* into China. In the present state of knowledge of the age of the Burmese faunas it is not possible to say whether *N. (N.) turcicus* is younger than *N. (N.) birmanicus*, but it may easily be distinguished from the latter species by the more pointed and considerably longer anterior border, the more convex preglabellar field, and the slightly narrower glabella. Reed's



paper (1915) shows that *N. (N.) birmanicus* possesses a pair of small paraglabellar areas, which were not apparent in the illustrations to his 1906 publication; it is not yet clear whether corresponding structures are present in *N. (N.) turcicus*, but the appropriate portion of the cranidium has not been found well preserved.

Family **EOHOMALONOTIDAE** Hupé, 1953

Genus **BRONGNIARTELLA** Reed, 1905

***Brongniartella levis*** sp. nov.

(Pl. 8, figs. 2, 3, 6)

DIAGNOSIS. Large species of *Brongniartella* with gently convex cranidium and scarcely defined glabella. Cranidium notably broad frontally with frontal margin only slightly convex forwards. Three pairs unequal glabellar lobes almost indistinguishable. Palpebral lobes opposite third glabellar furrows and some distance from glabella. Large, poorly-defined paraglabellar areas present.

HOLOTYPE. It. 1219.

LOCALITY AND HORIZON. Locality B.18 in the section west of Bedinan. The horizon is in the highest part of the mudstone/shale succession of the Bedinan Formation.

DESCRIPTION. The new species is represented with certainty by only a single incomplete, large cranidium of markedly depressed form. The median length is 51 mm., whilst the basal breadth must have been of the order of 80 mm., although the outer parts are incomplete. The glabella is subtrapezoidal in outline with a length of 35 mm., narrowing forwards from a basal breadth of about 36 mm. (estimated). The anterior and lateral margins are only poorly defined by furrows which are little more than broad, shallow indentations of the test. Glabellar lobation is almost indiscernible, in addition to being obscured by slight crushing of the test, but there are suggestions of three pairs of glabellar lobes of markedly unequal size, the basal pair being much the largest, occupying almost half the glabellar length. The second glabellar lobes are rather less than half the length of the basal pair, whilst the first pair are notably small, probably less than half the size of the second pair. There is a gentle, outwards curvature of the axial furrows opposite the second glabellar lobes, which project a little beyond the other pairs of lobes. The anterolateral angles of the glabella are slightly swollen dorsally to form a pair of low, lobe-like structures, between which the otherwise almost straight anterior margin of the glabella is slightly indented. Similar structures have been observed elsewhere in *Brongniartella*, *Neseuretus*, and other trilobites of the Calymenacea. A slight, longitudinal, median ridging of the centre of the glabella, though probably exaggerated by crushing, is undoubtedly original in part, and represents a feature known from other species of *Brongniartella*. The preglabellar field and anterior border cannot be differentiated but are combined to form a broad (*sag.*), scoop-like structure which is moderately arched transversely, gently inclined forwards, and has its dorsal surface slightly concave. The border is separated by only a pair of shallow

depressions from the anterior parts of the fixigenae, which are broad and gently declined abaxially. The anterior margin of the cranidium is broadly rounded in outline. The occipital ring is subrectangular in plan, its dorsal surface almost flat, whilst the occipital furrow is broad (*sag.*) and only lightly impressed, especially medially and abaxially where it is almost obsolete. It curves forwards slightly at its outer ends where the occipital ring passes almost imperceptibly into what remains of the posterior border. The palpebral lobes are set fairly well back, behind centre of the glabella and opposite the third glabellar furrows, and stand only slightly lower than the highest part of the cranidium. In plan they are moderately convex outwards, particularly well defined at their posterior ends, and carry no trace of palpebral furrows. The portions of the fixigenae behind the eyes are more steeply declined abaxially than are the anterior parts. They contain a pair of roughly quadrant-shaped paraglabellar areas which are large, extending forwards as far as the third glabellar furrows, but poorly defined by traces of shallow furrows. The facial suture is known from only the left anterior branch. This is sigmoidal in plan, at first curving forwards and slightly inwards from the eye, but then turning gently outwards until it reaches the cephalic border longitudinally almost in-line with the eye; finally it sweeps inwards in a broad curve to meet the cephalic margin approximately level with the posterolateral corner of the glabella. The surface of the test is smooth except for the extreme edge of the anterior border, which is finely granulated. In addition there are widely-spaced, conspicuous pits on the fixigenae anterior to the eye, whilst similar punctae are grouped more closely on the anterior half of the frontal cephalic border, forming a zone parallel to the anterior margin.

In addition to the holotype of *Brongniartella levis*, trilobite fragments assignable to the genus were found, though at other levels and localities, in the Bedinan Formation south-west of Bedinan (see Pl. 8, figs. 1, 5). All represent smaller individuals than the holotype and none is sufficiently well preserved for certain identification. An incomplete cranidium (Pl. 8, fig. 1) may represent an immature individual of *Brongniartella levis*. A fragmentary thorax and pygidium (Pl. 8, fig. 5) appear typical for the genus but are insufficient for detailed comparison.

DISCUSSION. *Brongniartella levis* is one of a group of broadly comparable species of the genus occurring over a wide area in rocks belonging to the lower or middle parts of the Caradoc Series. In the Anglo-Welsh area *Brongniartella caradociana* Dean (1961: 349), from the Costonian Stage [*Nemagraptus gracilis* Zone], is a slightly smaller species distinguished by having a more convex glabella, the anterior half of which becomes markedly narrower, and eyes set farther forwards than in the Turkish form. The well-known *Brongniartella bisulcata* M'Coy sp. (see Dean 1961: 346), from a Caradoc horizon roughly contemporaneous with that of *B. levis*, has the eyes a little farther forwards than the latter species, the sides of the glabella are less convergent forwards, and the cranidium is proportionately narrower frontally. *Brongniartella platynota* (Dalman) [= *B. inexpectata* Barrande sp., see Kielan 1960: 116] is a later form, apparently the last-known *Brongniartella*, widely distributed in the Ashgill Series of Central Europe and Scandinavia. It is easily distinguished from *B. levis* and other species of the genus by having the eyes

set well forwards, whilst the glabellar outline narrows markedly and the front of the cranidium is narrower and more convex in plan.

Genus **PLATYCORYPHE** Foerste, 1919

***Platycoryphe?*** sp.

(Pl. 8, fig. 4)

A single, small cranidium is tentatively assigned to *Platycoryphe*. The glabella has a basal breadth about one and a half times the median length (estd), there are three unequal pairs of glabellar lobes, and the outline narrows markedly in front of the second glabellar furrows. There is a suggestion of a right paraglabellar area but the eyes and the front of the cranidium are not preserved.

The problems of separating *Brongniartella* and *Platycoryphe* have been discussed elsewhere (Dean 1961; Whittington 1965). In general, the glabella of *Platycoryphe* is the more strongly segmented, a feature found in the present specimen. The specimen is, however, preserved as an internal mould, in which all cephalic furrows tend to appear deeper, and from the position of the glabellar furrows one cannot exclude the possibility of its being an immature example of *Brongniartella levis*. In the absence of the anterior border it seems better to refer the specimen, with some doubt, to *Platycoryphe*.

LOCALITY AND HORIZON. Locality B.20, in the Bedinan Formation west of Bedinan. The horizon is very close to others containing *Brongniartella* and the only other place where the two genera occur together is in South Shropshire, in the lowest subdivision of the Caradoc Series (Dean 1961).

Family **COLPOCORYPHIDAE** Hupé, 1953

Genus **COLPOCORYPHE** Novák *in* Perner, 1918

***Colpocoryphe*** sp.

(Pl. 9, figs. 5, 6-10)

This characteristically Mediterranean genus is represented in the Bedinan faunas by only three specimens, one reasonably complete and two fragmentary cranidia. The glabella seems relatively narrow for the genus, with a long, transversely rectangular, frontal glabellar lobe, and the axial furrows converge forwards only gently. The Turkish species, which may be new, is probably the youngest member of the genus yet recorded. *Colpocoryphe grandis* Šnajdr sp. (1956: 501, pl. 3, figs. 1-9), from the Drabov and Letná Beds (low Caradoc Series) of Bohemia, is broadly similar and has the eyes in a corresponding position, but differs in having more convergent axial furrows and a smaller, shorter frontal glabellar lobe.

FIGURED SPECIMENS. It. 1183 (Pl. 9, fig. 5); It. 1197 (Pl. 9, figs. 6-8, 10); It. 1204 (Pl. 9, fig. 9).

LOCALITIES AND HORIZONS. One specimen is from locality A.3, east of Sosink, whilst the others are from B.1 and B.2, south-west of Bedinan. All these localities are believed to be in the lower part of the Bedinan Formation, and *Colpocoryphe* is one of the trilobites common to both sections.

Family **ODONTOPLEURIDAE** Burmeister, 1843

Subfamily **SELENOPELTINAE** Whittington, 1956

Genus **SELENOPELTIS** Hawle & Corda, 1847

***Selenopeltis inermis*** (Beyrich) ***angusticeps*** subsp. nov.

(Pl. 10, figs. 1?, 4, 6?, 7, 8)

**DIAGNOSIS.** Subspecies of *S. inermis* characterized by having narrower glabella, with sides only slightly convex in plan. Eyes set less far apart than in *S. inermis*, and palpebral lobes less convex abaxially in plan. Frontal glabellar lobe has forked appearance owing to median depression extending backwards as far as second glabellar furrows.

**HOLOTYPE.** It. 1195 (Pl. 10, figs. 4, 7, 8).

**LOCALITIES AND HORIZONS.** The holotype is from locality A.2 in the section east of Sosink, whilst a small pygidium probably attributable to the same subspecies (see Pl. 10, fig. 6) was found nearby, at locality A.3. The only other specimen belonging, probably, to *S. inermis angusticeps*, is a fragmentary thorax (Pl. 10, fig. 1) from locality B.1, south-west of Bedinan. All these localities are believed to occur within the lower part of the Bedinan Formation.

**DESCRIPTION.** *Selenopeltis inermis* is a well-known species, widely distributed in Europe and the Mediterranean (Tethyan) Province, and its various subspecies extend with only relatively small modifications from the Arenig to Ashgill Series. Beyrich (1846: 20, pl. 3, figs. 2a-c) first described *S. inermis* from "Wessela", Bohemia, whilst the lectotype of *Selenopeltis buchi* (Barrande 1846: 28), a species considered by Whittard (1961: 197) to be a subjective synonym of *S. inermis*, came from the Chlustina Beds (Caradoc Series) of Zahorany, Bohemia (see Šnajdr 1956: 501). The holotype cranium of *S. inermis angusticeps* is broadly comparable with published illustrations of the Bohemian species but may be distinguished by the features listed in the diagnosis. In particular the glabellar sides of the Turkish form appear almost straight by comparison, whilst the distance from the palpebral lobe to the axial line is conspicuously less than in the Czech specimens. The fragment of thorax from east of Sosink shows no diagnostic features but the small pygidium from near Bedinan, although close to that of *S. inermis inermis*, appears to be slightly longer and has a median indentation of the margin. However, this specimen is too poorly preserved for detailed comparison and neither it nor the thoracic fragment is included as type material. *S. inermis angusticeps* is not yet known from anywhere but the Sosink-Bedinan region but it is interesting to note that Seilacher (1963: 530, fig. 2) has recorded *Selenopeltis buchi* from the Sinat Shales in northernmost Iraq, not far to the east of the Turkish outcrops.

Family **ASAPHIDAE** Burmeister, 1843

**Asaphid** gen. et sp. indet.

(Pl. 10, figs. 2, 5)

A single hypostoma, figured here as an internal mould and a latex cast of the corresponding external mould, is the only evidence of asaphid trilobites yet known



from the Bedinan Formation. The maximum breadth, measured almost across the centre, is estimated as about three-quarters of the maximum length. The overall outline is suboval but the posterior margin is bifid, with a large, parabolic, median indentation extending for about one quarter of the length of the entire hypostoma. There is a large, subcircular, median lobe of low convexity, circumscribed by a furrow which is deepest posterolaterally. The median lobe is separated from the apex of the median indentation by a narrow (*sag.*), flat strip equal to about one tenth of the total length of the hypostoma, and ending laterally in a pair of poorly-defined maculae. Although the front of the hypostoma is incomplete, and there is no trace of anterior wings, there is a flattened lateral border, bearing terrace-lines on its dorsal surface, which is continuous with the bifurcated posterior border.

FIGURED SPECIMEN. It. 1203.

LOCALITY AND HORIZON. Locality A.6, east of Sosink, the highest fossiliferous horizon in this particular section.

#### VI. REFERENCES

- BARRANDE, J. 1846. *Notice préliminaire sur le Système Silurien et les trilobites de Bohême.* vi + 91 pp. Leipzig.
- 1852. *Système silurien du centre de la Bohême. Ière partie. Recherches paléontologiques.* xxx + 935 pp., 51 pls. Prague & Paris.
- BEYRICH, E. 1846. *Untersuchungen über Trilobiten.* 37 pp., 4 pls. Berlin.
- BOUČEK, B. 1937. Stratigraphie et parallélisme de l'Ordovicien supérieur de la Bohême. *Bull. Soc. géol. Fr.*, Paris (5) **7** : 439-458, pls. A-C.
- COOPER, B. N. 1953. Trilobites from the Lower Champlainian formations of the Appalachian Valley. *Mem. geol. Soc. Am.*, Washington, **55** : 1-69, pls. 1-19.
- DEAN, W. T. 1961. The Ordovician trilobite faunas of South Shropshire, II. *Bull. Br. Mus. nat. Hist. (Geol.)*, London, **5** : 311-358, pls. 49-55.
- 1967. The distribution of Ordovician shelly faunas in the Tethyan region. *Systematics Assoc.*, London [in press].
- EMMRICH, H. F. 1839. *De Trilobitis.* 56 pp., 1 pl. Berlin.
- HAVLÍČEK, V. 1950. The Ordovician Brachiopoda from Bohemia. *Rozpr. Ústřed. Úst. geol.*, Prague, **13** : 1-133, pls. 1-13. [In Czech, with English and Russian summaries]
- HAVLÍČEK, V., HORNÝ, R., CHLUPAČ, I. & ŠNAJDR, M. 1958. Führer zu den Geologischen Exkursionen in das Barrandium. *Sbír. geol. Prův.*, Prague, **1** : 1-171, pls. 1-16.
- KELLOGG, H. E. 1960. The geology of the Derik-Mardin area, south-eastern Turkey. *Rept Explor. Divn Amer. Overseas Petr. Ltd*, Ankara [unpublished].
- KIELAN, Z. 1960. Upper Ordovician trilobites from Poland and some related forms from Bohemia and Scandinavia. *Palaeont. pol.*, Warsaw, **11** : 1-198, pls. 1-36.
- KOBAYASHI, T. 1940. Notes on the Dionideidae. *Jap. J. Geol. Geogr.*, Tokyo, **17** : 203-208.
- LU, Y. H. 1957. *Index fossils of China. Invertebrate, Pt. 3, Trilobita.* *Acad. sinica*, Peking : 249-294, pls. 137-155.
- MANSUY, H. 1912. Étude géologique du Yun-nan Oriental. IIe partie, Paléontologie. *Mém. Serv. géol. Indoch.*, Hanoi, **1**, 2 : 1-146, pls. 1-25.
- MAREK, L. 1952. Contribution to the stratigraphy and fauna of the uppermost part of the Králův Dvůr Shales (Ashgillian). *Sborník Ústřed. Úst. geol.*, Prague, **19** : 429-455, 2 pls. [In Czech, with Russian and English summaries.]
- OEHLERT, D.-P. 1895. Sur les *Trinucleus* de l'Ouest de la France. *Bull. Soc. géol. Fr.*, Paris, **23** : 299-336, pls. 1, 2.

- REED, F. R. C. 1906. The Lower Palaeozoic fossils of the Northern Shan States, Burma. *Palaeont. indica*, Calcutta (N.S.), **2**, 3 : 1-154, pls. 1-8.
- 1915. Supplementary Memoir on new Ordovician and Silurian fossils from the Northern Shan States. *Palaeont. indica*, Calcutta (N.S.), **6**, 1 : 1-98, pls. 1-12.
- SCHMIDT, G. C. 1965. Chart 1. Proposed Rock Unit Nomenclature, Petroleum District V, S.E. Turkey. Revised Edn. *Stratigraphic Committee, Turkish Assoc. Petroleum Geologists*, Ankara. [unpublished].
- SEILACHER, A. 1963. Kaledonischer Unterbau der Irakiden. *Neues Jb. Miner. Geol. Paläont. Mh.*, Stuttgart, **10** : 527-542, figs. 1-3.
- ŠNAJDR, M. 1956. The trilobites from the Drabov and Letná Beds of the Ordovician of Bohemia. *Sb. ústřed. Úst. geol.*, Prague, **22** : 477-533, pls. 32-37. [In Czech, with English and Russian summaries.]
- TOLUN, N. 1960. Stratigraphy and Tectonics of southeastern Anatolia. *Rev. Fac. Sci. Univ. Istanbul*, B **25** : 201-264, 2 pls.
- TOLUN, N. & TERNEK, Z. 1952. Notes géologiques sur la région de Mardin. *Türk. Jeol. Kür. Bült.* Ankara, **3** : 1-19, 5 pls.
- WHITTARD, W. F. 1955. The Ordovician trilobites of the Shelve Inlier, West Shropshire, I. *Palaeontogr. Soc. [Monogr.]*, London : 1-40, pls. 1-4.
- 1956. The Ordovician trilobites of the Shelve Inlier, West Shropshire, II. *Palaeontogr. Soc. [Monogr.]*, London : 41-70, pls. 5-9.
- 1958. The Ordovician trilobites of the Shelve Inlier, West Shropshire, III. *Palaeontogr. Soc. [Monogr.]*, London : 71-116, pls. 10-15.
- 1959. The Ordovician trilobites of the Shelve Inlier, West Shropshire, IV. *Palaeontogr. Soc. [Monogr.]*, London : 117-162, pls. 16-21.
- 1961. The Ordovician trilobites of the Shelve Inlier, West Shropshire, V. *Palaeontogr. Soc. [Monogr.]*, London : 163-196, pls. 22-25.
- 1961. The Ordovician trilobites of the Shelve Inlier, West Shropshire, VI. *Palaeontogr. Soc. [Monogr.]*, London : 197-228, pls. 26-33.
- WHITTINGTON, H. B. 1940. On some Trinucleidae described by Joachim Barrande. *Amer. J. Sci.*, Washington, **238** : 241-259, pls. 1-4.
- 1950. Sixteen Ordovician genotype trilobites. *J. Paleont.*, Menasha, **24** : 531-565, pls. 68-75.
- 1952. The trilobite family Dionididae. *J. Paleont.*, Menasha, **26** : 1-11, pls. 1, 2.
- 1959. Silicified Middle Ordovician trilobites: Remopleurididae, Trinucleidae, Raphiophoridae, Endymioniidae. *Bull. Mus. comp. Zool. Harv.*, **121** : 369-496, pls. 1-36.
- 1962. A Monograph of the Ordovician trilobites of the Bala area, Merioneth, I. *Palaeontogr. Soc. [Monogr.]*, London : 1-32, pls. 1-8.
- 1965. *Platycoryphe*, an Ordovician homalonotid trilobite. *J. Paleont.*, Menasha, **39** : 487-491, pl. 64.
- 1966. Phylogeny and distribution of Ordovician trilobites. *J. Paleont.*, Menasha, **40** : 696-737, 16 figs.
- WILLIAMS, A. 1948. The Lower Ordovician Cryptolithids of the Llandeilo District. *Geol. Mag. Lond.*, **85** : 65-88, pl. 6.
- YI, Y. E. 1957. The Caradocian trilobite fauna from the Yangtze-Gorges. *Acta palaeont. sinica*, Peking, **5** : 545-559, pls. 1-5.